IDAHO DEPARTMENT OF FISH AND GAME

Joseph C. Greenley, Director

LAKE AND RESERVOIR INVESTIGATIONS

Job Performance Report

F-53-R-10

Job IV-a. Lake Pend Oreille Creel Census

by
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Job IV-b. Clark Fork River Census

by
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Job IV-c. Kokanee Spawning Trends

by
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Job IV-d. Lake Pend Oreille Limnological Studies

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Job IV-e. Lake Pend Oreille Kokanee Life History Studies

by
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Period Covered: 1 March 1974 to 28 February 1975

June, 1975

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JOB PERFORMANCE REPORT

State of Idaho

Project No. F-53-R-10

Job No. IV-a

Name: LAKE AND RESERVOIR INVESTIGATIONS

Title: Lake Pend Oreille Creel Census--1974

Period Covered: 1 March 1974 to 28 February 1975

ABSTRACT:

In 1974, anglers fished an estimated 226,973 hours during 49,206 man-days to catch 327,302 fish at Lake Pend Oreille. Kokanee and trout comprised 97% and 2% of the estimated catch, respectively. No commercial fishing for kokanee and whitefish occurred at Lake Pend Oreille in 1974.

Hatchery personnel have released 618,139 marked Kamloops rainbow since 1968. To date, an estimated 408 of 502,835 clipped fish have been caught.

Approximately 98% of the anglers fishing Pend Oreille in 1974 resided in the Pacific and Mountain states with from other states and foreign countries. In Idaho, Bonner and Kootenai.. counties contributed 74% of the state's anglers and 33% of all anglers fishing the lake. hake Pend Oreille received no excessive pressure from visitors to Expo '74.

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Continue the creel census on Lake Pend Oreille and include the Kamloops Resort in Lieu of the (Hope access.

Mark all Kamloops and Dolly Varden (with the exception of fry) planted the lake or tributary streams.

OBJECTIVES:

To provide estimates of angling pressure and harvest of important sport Fishes to:

1. determine the size and age composition of the catch of major species,
2. determine the contribution of hatchery-reared fish to the fishery, and
3. evaluate trends of the fisheries and recommend management procedures.

TECHNIQUES USED:

Creel census

The creel census was similar to that used during the previous 3 years.

Project personnel censused 12 landings between 13 January and 30 November 1971. Each landing was censused 3 Saturdays, 3 Sundays and 3 weekdays per 46-day period. The annual census was divided into 21 two-week intervals to separate error due to seasons and to provide a seasonal catch comparison.

Expansion of the census data was projected by class-day for 2-week intervals for the entire year. For example, I defined an angler man-day as one angler fishing one day regardless of actual time spent fishing. Projection to estimated angler man-days is obtained by multiplying the number of inter-viewed anglers on a given day by the number of class-days (either weekdays or weekend days) within a 2-week interval. In reports prior to 1971, angler man days were referred to as the total number of anglers.

Marked Kamloops rainbow releases

Hatchery personnel have released 618,139 Kamloops rainbow in Lake Pend Oreille and its tributaries since 1968 with 81% marked. They also planted 2,409,990 unmarked Kamloops fry and 4,072,942 unmarked Dolly Varden fry.

FINDINGS:

Kokanee catch

Sport harvest

In 1974, anglers fished an estimated 226,973 hours during 49,206 man-

days to catch 327,302 fish between 13 January and 30 November (Table 1). Eighty-one percent of the anglers sought kokanee which made up 97% of the estimated catch while 28% sought trout, which comprised 2% of the estimated catch. A small percentage of anglers sought spiny-ray game fish. The 1951-1974 pressure and catch statistics are summarized in Appendix I.

Resident sport harvest

Resident sport anglers expended 46% (104,936) of the estimated effort (hours fished), harvested 42% (137,642) of the estimated catch and 42% (132,981) of the kokanee catch (Table 2).

Nonresident sport harvest

Nonresident sport anglers comprised 54% (122,037) of the estimated effort, harvested 58% (189,660) of the estimated catch and 58% (186,305) of the kokanee catch (Table 3).

Catch rates

Interviewed anglers seeking kokanee fished 45,087 hours to catch 83,210 kokanee and averaged 1.8 fish per hour (Table 4). Kokanee anglers, incident-ally, caught 903 other game fish, mostly rainbow and cutthroat.

Age composition and poundage

At intervals, throughout the year, project personnel measured 2,928 angler-caught kokanee and 530 spawning kokanee to assess age and growth of the fish (Table 5). Length distributions of these fish indicate the range of sizes for each age class and contribution of each year class to the fishery. However, owing to a possible restructuring of kokanee age classes at Pend Oreille, poundage by year class will not be attempted until newly acquired information is analyzed.

Trout catch

Kamloops rainbow

In 1974, sport anglers seeking Kamloops rainbow expended an average of 49.5 hours to catch each fish and 80.1 hours to catch each trophy fish (Table 6). They harvested 4,337 Kamloops rainbow including 737 trophy fish (over 342 mm) (17 in).

Measured Kamloops (1,286) ranged between 178 and 902 mm (7 and 35.5 in) with an average length of 384 mm (15.1 in). Trophy Kamloops averaged 673 mm (26.5 in) and 4.7 kg (10.3 lb) (Appendix I, Table 8).

Marked Kamloops

Hatchery personnel have released 618,139 Kamloops rainbow in Lake Pend Oreille and its tributaries since 1968 of which 81% have been marked (Table 7). To date, an estimated 408 of 502,835 clipped fish have been caught (one of every 1,232 released).

Since 1969, census personnel have observed 90 fin clipped Kamloops. These fish ranged between 203 and 452 mm (8 and 17.8 in) and averaged 292 mm (11.5 in) in length. Only one of 849 trophy Kamloops observed by census personnel during the past 4 years was clipped.

In 1974, 1% of the interviewed Kamloops anglers sought small rainbow, but all clipped returnees, as in previous years, were caught by anglers seeking other species.

Other trout

Anglers seeking trout expended 18.5 hours per fish in 1974 (Table 8). They harvested an estimated 847 Dolly Varden (including 466 trophy fish), 500 cutthroat trout and 5 brown trout (Appendix I, Table 8).

Dolly Varden measurements (304) ranged between 229 and 838 mm (9 and 33 in) with average length of 455 mm (17.9 in). Trophy Dolly Varden averaged 541 mm (21.3 in) and 2.1 kg (4.6 lb) (Appendix I, Table 9).

Cutthroat (144) measured between 152 and 444 mm (6 and 17.5 in) with an average length of 315 mm (12.4 in).

One trophy brown trout measured 432 mm (17 in) and weighed 0.9 kg (2 lb). The other measured 330 mm (13 in).

Angler residency

During the creel census, project personnel interviewed 13,121 anglers to determine their home residency (Appendix II). Fifty percent (6,580) of the anglers came from the Pacific states and 48% (6,337) resided in the Mountain states with 45% (5,859) from Idaho alone. Approximately 2% (204) came from other states and foreign countries.

Residents from the ten North Idaho counties comprised 98% (5,756) of the Idaho anglers. Bonner and Kootenai counties produced 74% (4,329) of the Idaho anglers and 33% of all anglers.

In the past 2 years, 98% of the anglers fishing Pend Oreille resided in the Pacific and Mountain states. Evidently, Lake Pend Oreille received no excessive pressure from visitors to Expo '74.

Kamloops Resort evaluation*

A gradual reduction in angler access use at Hope since the early sixties prompted a low-profile census at the Kamloops Resort near Trestle Creek.

Between 25 July and 27 August, sport anglers using the Kamloops Resort access caught 6,492 kokanee. Although the length of the creel census at the Kamloops Resort was significantly less than at other landings, the kokanee catch there could have increased the overall kokanee catch by 2% from 319,286 to 325,778.

*Information not included as part of the 1974 Lake Pend Oreille estimates.

Table 1. Estimated minimum fishing pressure, effort and harvest, Lake Pend Oreille, Idaho, 1974.

Period	Angler man-days	Hours	Kokanee	Cut-throat	Dolly Varden	Rain-bow	White-fish	Spiny-rays	Other trout	Non-game
13 Jan.-27 Feb.	382	1,395	1,868	--	--	--	82	--	--	--
28 Feb.-14 Apr.	1,166	5,534	9,930	--	--	--	3	--	--	3
15 Apr.-30 May	4,906	26,195	7,259	44	462	726	72	178	--	20
31 May-15 July	13,734	62,734	74,917	234	243	1,845	264	152	3	86
16 July-30 Aug.	15,279	66,784	122,350	145	26	1,004	50	194	17	28
31 Aug.-15 Oct.	11,085	51,401	101,269	75	84	635	3	58	--	11
16 Oct.-30 Nov.	2,654	12,930	1,693	2	32	127	1,108	--	--	--
Totals	49,206	226,973	319,286	500	847	4,337	1,582	582	20	148

Table 2. Resident sport fishing pressure, effort and harvest, Lake Pend Oreille, Idaho, 1974.

Period	Angler man-days	Hours	Kokanee	Cut-throat	Dolly Varden	Rain-bow	White-fish	Spiny-rays	Other trout	Non-game
13 Jan.-27 Feb.	342	1,203	1,334	--	--	--	62	--	--	--
28 Feb.-14 Apr.	947	4,404	7,997	--	--	--	3	--	--	3
15 Apr.-30 May	3,068	16,826	4,870	22	320	334	36	176	--	16
31 May-15 July	6,549	30,403	37,469	65	80	784	230	133	3	81
16 July-30 Aug.	5,277	23,771	38,852	81	16	383	19	118	11	22
31 Aug.-15 Oct.	4,569	21,790	42,005	40	35	359	3	58	--	--
16 Oct.-30 Nov.	1,372	6,539	454	2	14	88	1,064	--	--	--
Totals	22,124	104,936	132,981	210	465	1,948	1,417	485	14	122

Table 3. Nonresident sport fishing pressure, effort and harvest, Lake Pend Oreille, Idaho, 1974.

Period	Angler man-days	Hours	Kokanee	Cut-throat	Dolly Varden	Rain-bow	White-fish	Spiny-rays	Other trout	Non-game
13 Jan.-27 Feb.	40	192	534	--	--	--	20	--	--	--
28 Feb.-14 Apr.	219	1,130	1,933	--	--	--	--	--	--	--
15 Apr.- 30 May	1,838	9,369	2,389	22	142	392	36	2	--	4
31 May-15 July	7,185	32,331	37,448	169	163	1,061	34	19	--	5
16 July-30 Aug.	10,002	43,013	83,498	64	10	621	31	76	6	6
31 Aug.-15 Oct.	6,516	29,611	59,264	35	49	276	--	--	--	11
16 Oct.-30 Nov.	1,282	6,391	1,239	--	18	39	44	--	--	--
Totals	27,082	122,037	186,305	290	382	2,389	165	97	6	26

Table 4. Catch data for interviewed anglers seeking kokanee, Lake Pend Oreille, Idaho, 1974.

Month	Anglers	Hours	Kokanee	Other game fish	Kokanee per hour	All game fish per hour	Kokanee per angler
January	5	23	--	--	0.0	0.0	0.0
February	97	421	655	--	1.6	1.6	6.8
March	357	1,627	2,411	--	1.5	1.5	6.8
April	98	398	23	--	0.1	0.1	0.2
May	528	2,055	2,289	84	1.1	1.1	4.3
June	2,163	9,335	17,235	357	1.8	1.9	8.0
July	2,274	9,992	16,165	211	1.6	1.6	7.1
August	2,100	8,957	17,006	142	1.9	1.9	8.1
September	1,989	9,184	22,084	93	2.4	2.4	11.1
October	660	3,063	5,329	16	1.7	1.7	8.1
November	12	32	13	--	0.4	0.4	1.1
Totals	10,283	45,087	83,210	903			
Average (weighted)					1.8	1.9	8.1

Table 5. Length frequency distribution of 2,928 kokanee from the catch and 530 kokanee from the spawning population, Lake Pend Oreille, Idaho, 1974.

Length group (mm)	1974 Creel census						1974 Spawners		
	13 Jan.-27 Feb.	28 Feb.-14 Apr.	15 Apr.-30 May	31 May-15 July	16 July-30 Aug.	31 Aug.-15 Oct.	Males	Females	Total
140-4		2							
145-9									
150-4									
155-9									
160-4	2	1							
165-9		1		2	1				
170-4				5	3				
175-9				3	10				
180-4		2		2	16				
185-9		1		2	10	4			
190-4	1	1		3	10	11			
195-9	5	2	3	4	9	13			
200-4	8	21	5	16	9	15			
205-9	19	17	9	31	19	6			
210-4	32	35	20	47	32	5			
215-9	37	46	42	64	35	11			
220-4	53	63	65	91	53	15			
225-9	52	49	102	107	61	8			
230-4	53	35	120	105	90	6			
235-9	22	15	97	69	74	25		2	2
240-4	12	7	41	35	90	77		7	7
245-9	2	2	15	10	40	90	4	20	24
250-4	1		4	3	22	122	27	59	86
255-9	1				11	95	36	83	119
260-4					5	58	52	53	105
265-9						31	59	28	87
270-4				1		8	56	8	64
275-9			2				16	4	20
280-4			1				13	2	15
285-9							1		1

Table 5. Length frequency distribution of 2,928 kokanee from the catch and 530 kokanee from the spawning population, Lake Pend Oreille, Idaho, 1974 (continued).

Length group (mm)	1974 Creel census						1974 Spawners		
	13 Jan.-27 Feb.	28 Feb.-14 Apr.	15 Apr.-30 May	31 May-15 July	16 July-30 Aug.	31 Aug.-15 Oct.	Males	Females	Total
365-9			1						
370-4									
375-9									
380-4			1						
Totals	300	300	528	600	600	600	264	266	530

Table 6. Catch data for interviewed anglers seeking Kamloops rainbow trout (all sizes), Lake Pend Oreille, Idaho, 1974*.

Month	Anglers	Hours	Kamloops rainbow	Other trout	Other game fish	Kamloops rainbow per hour	All trout per hour	All game fish per hour
May	1,022	6,044	125	28	1	0.02	0.03	0.03
June	550	2,848	64	15	11	0.02	0.03	0.03
July	306	1,619	45	9	2	0.03	0.03	0.03
August	214	1,016	21	6	4	0.02	0.03	0.03
September	269	1,110	43	20	1	0.04	0.06	0.06
October	466	2,386	19	19	--	0.01	0.02	0.02
November	336	1,721	21	5	--	0.01	0.02	0.02
Totals	3,163	16,744	338*	102	19			
Average (weighted)						0.02	0.03	0.03

*Includes 207 trophy Kamloops rainbow caught in 16,571 hours.

Table 7. Total marked Kamloops rainbow releases and returns of marked Kamloops rainbow to the creel, Lake Pend Oreille, Idaho, 1968-1974.

Year	Adipose clip only	Adipose combination clip*	Total clipped	Total released	Percent clipped	Estimated number returned		Total returned
						Adipose clip only	Adipose combination clip	
1968	141,752	-	141,752	144,002	98	-	-	-
1969	100,530	-	100,530	119,676	84	51	-	51
1970	13,390	71,230	84,620	89,180	95	14	-	14
1971	510	32,315	32,825	66,652	49	128	2	130
1972	-	56,237	56,237	56,237	100	23	-	23
1973	-	69,474	69,474	69,474	100	8	85	93
1974	-	17,397	17,397	72,918	24	13	84	97
Totals	256,182	246,653	502,835	618,139	81	237	171	408

*An adipose combination clip is either an adipose-right ventral or adipose-left ventral fin clip.

Table 8. Catch data for interviewed anglers seeking trout, all species combined, Lake Pend Oreille, Idaho, 1974.

Month	Anglers	Hours	Trout	Other game fish	Trout per hour	All game fish per hour
May	1,238	7,231	377	56	0.05	0.06
June	644	3,269	226	156	0.07	0.12
July	349	1,809	136	68	0.08	0.11
August	236	1,123	58	15	0.05	0.06
September	302	1,237	138	21	0.11	0.13
October	481	2,454	58	9	0.02	0.03
November	341	1,737	27	1	0.02	0.02
Totals	3,591	18,860	1,020	326		
Average (weighted)					0.05	0.07

Table 1. Estimated minimum number of angler man-days by license class, Lake Pend Oreille, Idaho, 1951 - 1974.

Year	Total	Resident	Nonresident	Commercial
1951	60,172	--	--	--
1952	57,814	26,836	30,051	927
1953	99,855	47,786	44,877	7,192
1954	90,566	40,956	41,619	7,991
1955	67,645	31,386	32,257	4,002
1956	87,813	45,432	38,006	4,375
1957	72,355	35,207	34,229	2,919
1958	88,453	45,532	36,862	6,059
1959	75,057	36,671	34,914	3,472
1960	77,162	35,564	36,385	5,213
1961	81,387	33,648	42,453	5,286
1962	59,379	23,656	31,348	4,375
1963	72,221	31,788	35,805	4,628
1964	66,225	26,703	35,295	4,227
1965	58,263	27,440	26,256	4,567
1966	65,340	24,710	37,976	2,654
1967	54,699	20,564	31,559	2,576
1968	55,414	18,379	35,492	1,543
1969	45,025	17,549	26,606	870
1970	61,815	21,944	37,715	2,156
1971	60,137	23,751	33,790	2,596
1972	50,506	21,214	26,971	2,321
1973	46,582	19,929	25,873	780
1974	49,206	22,124	27,082	--

Table 2. Estimated minimum number of hours fished by license class--Lake Pend Oreille, Idaho, 1951-1974.

Year	Total	Resident	Nonresident	Commercial
1951	330,923	--	--	--
1952	308,850	133,539	169,372	5,939
1953	522,692	234,173	242,764	45,755
1954	459,271	189,920	221,512	47,839
1955	327,551	139,639	163,819	24,093
1956	406,538	196,226	181,397	28,915
1957	331,476	148,236	165,556	17,684
1958	400,683	192,199	171,033	37,451
1959	345,406	162,296	162,830	20,280
1960	372,266	162,531	176,806	32,929
1961	384,702	156,142	192,610	35,950
1962	274,554	108,380	138,339	27,835
1963	350,128	154,371	165,126	30,631
1964	314,220	125,842	164,446	23,932
1965	281,230	128,817	126,334	26,079
1966	295,781	113,085	166,206	16,490
1967	245,837	95,147	133,442	17,248
1968	242,859	83,200	150,157	9,502
1969	197,202	83,349	109,106	4,747
1970	261,785	91,878	157,446	12,461
1971	265,514	107,753	141,844	15,917
1972	222,908	96,097	113,475	13,336
1973	211,034	92,099	115,292	3,643
1974	226,973	104,936	122,037	--

Table 3. Estimated minimum catch of kokanee by license class--Lake Pend Oreille, Idaho, 1951-1974.

Year	Total	Resident	Nonresident	Commercial
1951	820,486	--	--	170,500
1952	514,913	183,657	268,116	63,140
1953	1,335,881	412,288	382,593	541,000
1954	1,232,916	326,568	362,844	543,504
1955	650,375	181,492	228,610	240,273
1956	1,092,651	423,092	240,294	429,265
1957	751,113	256,280	277,699	217,134
1958	1,197,426	365,082	359,132	473,212
1959	1,161,913	377,065	332,001	452,847
1960	1,039,200	320,041	278,571	440,588
1961	991,955	257,362	305,361	429,232
1962	650,960	168,847	190,039	292,074
1963	1,049,339	359,677	314,291	375,371
1964	1,162,625	357,152	452,962	352,511
1965	1,007,292	385,007	319,034	303,251
1966	808,744	220,317	351,403	237,024
1967	710,312	218,629	290,081	201,602
1968	618,405	207,058	288,454	122,893
1969	483,292	180,294	242,109	60,889
1970	654,848	173,672	367,981	113,195
1971	590,058	189,377	242,383	158,298
1972	521,048	172,952	186,499	161,597
1973	328,739	127,291	195,767	5,681
1974	319,286	132,981	186,305	--

Table 4. (Part 1). Lake Pend Oreille kokanee catch by month, 1951-1958.

Year	Kokanee catch by month											Total catch
	January	February	March	April	May	June	July	August	September	October	November	
1951		⟵ 315,852 ⟶		27,781	50,508	183,882	88,248	43,706	84,234	26,275		820,486
1952				14,379	126,979	107,521	79,405	39,056	66,172	81,401		514,913
1953		50,466	255,549	203,791	190,203	234,300	140,141	56,206	95,779	107,144	2,302	1,335,881
1954		8,963	96,637	180,081	358,689	203,896	192,094	50,018	93,946	46,806	1,786	1,232,916
1955		24	23,762	61,515	200,674	99,188	23,388	67,792	136,641	37,383	8	650,375
1956	433	3,359	212,597	299,637	226,911	64,036	66,619	55,985	142,753	20,289	32	1,092,651
1957		39,885	85,926	129,715	102,188	38,454	42,147	88,447	196,838	27,499	14	751,113
1958	26,400	105,974	81,481	200,611	227,203	42,356	101,736	117,508	223,693	70,459	5	1,197,426

Table 4. (Part 2). Lake Pend Oreille kokanee catch by period, 1959-1974.

Year	Kokanee catch by period							Total catch
	13 Jan.-27 Feb.	28 Feb.-14 Apr.	15 Apr.-30 May	31 May-15 July	16 July-30 Aug.	31 Aug.-15 Oct.	16 Oct.-30 Nov.	
1959	--	233,599	380,173	270,127	113,144	158,622	6,248	1,161,913
1960	19,042	287,126	307,945	131,586	72,112	201,303	20,086	1,039,200
1961	77	239,822	347,946	98,447	41,587	260,326	3,750	991,955
1962	24,005	117,808	240,200	79,608	72,440	103,005	13,894	650,960
1963	212,175	130,142	261,372	55,511	150,634	221,355	18,150	1,049,339
1964	90,162	160,011	293,894	196,037	145,106	273,720	3,695	1,162,625
1965	120,193	287,280	157,907	147,746	36,761	254,740	2,665	1,007,292
1966	72,766	146,076	170,690	95,038	139,628	178,218	6,328	808,744
1967	125,435	62,274	107,762	169,990	73,220	165,761	5,870	710,312
1968	126,179	4,968	99,692	136,559	114,754	136,235	18	618,405
1969	9,266	10,378	124,940	92,529	105,186	135,507	5,486	483,292
1970	50,050	65,378	50,296	190,340	157,069	141,132	583	654,848
1971	24,497	74,938	145,830	167,243	68,129	108,092	1,329	590,058
1972	23,617	129,054	116,514	64,024	88,154	98,955	730	521,048
1973	1,935	8,868	7,607	83,740	113,399	112,676	514	328,739
1974	1,868	9,930	7,259	74,917	122,350	101,269	1,693	319,286

Table 5. Catch per hour by month for interviewed anglers (including commercial) seeking kokanee, Lake Pend Oreille, Idaho, 1954-1974.

Year	Monthly catch per hour for kokanee											
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Avg.
1954	-	0.8	4.5	5.9	5.2	2.8	2.4	1.4	1.5	2.5	1.3	2.9
1955	-	0.5	3.2	4.3	7.2	2.6	0.7	1.4	1.5	2.4	0.0	2.4
1956	3.5	6.5	7.5	6.2	6.2	1.7	1.1	1.4	2.3	2.7	0.2	3.3
1957	-	5.5	5.1	4.5	4.8	1.3	1.4	2.2	2.8	2.5	-	2.9
1958	7.9	3.4	4.6	8.1	5.2	1.4	1.9	2.6	3.7	3.3	1.0	3.6
1959	-	-	6.6	7.4	6.1	3.0	2.1	1.9	3.1	2.8	-	3.7
1960	0.9	5.3	7.8	4.1	6.4	2.3	1.1	1.6	2.0	2.5	0.3	3.2
1961	0.2	0.7	7.1	2.7	4.4	1.6	1.2	1.1	2.2	2.6	-	2.7
1962	-	5.2	2.5	4.8	4.9	1.4	1.2	1.5	1.7	3.7	0.0	2.6
1963	-	11.4	3.6	2.6	4.3	1.4	2.1	2.5	2.5	4.0	0.2	3.3
1964	3.5	7.3	6.4	4.4	8.6	3.0	1.8	3.1	4.1	3.2	3.7	4.5
1965	6.2	6.7	8.0	2.3	5.4	3.1	1.9	2.2	3.4	3.6	0.0	4.2
1966	11.6	7.1	4.4	0.4	4.8	1.9	1.6	2.6	2.7	2.6	-	3.1
1967	9.5	7.8	3.8	1.3	5.6	2.4	2.0	2.3	3.2	3.8	0.0	3.5
1968	13.3	6.4	0.1	3.7	3.9	2.8	1.7	2.4	2.7	2.4	-	2.9
1969	6.7	2.7	1.7	1.0	6.9	2.0	2.6	2.7	3.3	2.0	0.5	3.5
1970	0.7	3.9	6.2	0.8	3.1	2.4	2.7	3.0	2.9	2.4	0.0	2.9
1971	2.9	1.9	3.6	3.4	4.3	2.3	1.7	1.9	2.1	2.0	0.3	2.6
1972	8.9	6.0	6.1	2.0	4.0	2.1	1.7	2.0	2.3	1.4	1.0	2.8
1973	0.4	0.6	0.8	0.9	0.7	1.7	1.9	2.3	2.4	1.5	0.0	1.9
1974	0.0	1.6	1.5	0.1	1.1	1.8	1.6	1.9	2.4	1.7	0.4	1.8

Table 6. Average kokanee size at spawning time, Pend Oreille Lake, Idaho, 1950-1974.

Year	No. of females	Average length mm (in)	No. of males	Average length mm (in)	Total	Average length mm (in)
1950	-	-	-	-	12	277 (10.9)
1951	29	287 (11.3)	22	302 (11.9)	51	292 (11.5)
1952	158	302 (11.9)	137	310 (12.2)	295	305 (12.0)
1953	949	287 (11.3)	942	302 (11.9)	1,891	295 (11.6)
1954	123	267 (10.5)	102	277 (10.9)	225	272 (10.7)
1955	181	259 (10.2)	193	272 (10.7)	374	264 (10.4)
1956	339	254 (10.0)	322	264 (10.4)	661	259 (10.2)
1957	-	254 (10.0)	-	264 (10.4)	-	259 (10.2)
1958	621	262 (10.3)	832	272 (10.7)	1,453	267 (10.5)
1959	451	267 (10.5)	563	277 (10.9)	1,014	272 (10.7)
1960	239	274 (10.8)	300	290 (11.4)	539	284 (11.2)
1961	341	279 (11.0)	408	290 (11.4)	749	284 (11.2)
1962	229	279 (11.0)	423	290 (11.4)	652	284 (11.2)
1963	160	267 (10.5)	141	279 (11.0)	301	272 (10.7)
1964	48	244 (9.6)	72	256 (10.1)	120	251 (9.9)
1965	88	267 (10.5)	110	259 (10.2)	198	262 (10.3)
1966	104	269 (10.6)	120	262 (10.3)	224	264 (10.4)
1967	80	254 (10.0)	79	267 (10.5)	159	259 (10.2)
1968	-	-	-	-	-	-
1969	-	-	-	-	103	259 (10.2)
1970	163	262 (10.3)	160	272 (10.7)	323	267 (10.5)
1971	150	262 (10.3)	150	272 (10.7)	300	267 (10.5)
1972	180	256 (10.1)	202	262 (10.3)	382	259 (10.2)
1973	165	254 (10.0)	193	264 (10.4)	358	259 (10.2)
1974	266	256 (10.1)	264	264 (10.4)	530	262 (10.3)

Table 7. Relationship between kokanee catch and drawdown after 15 November, Lake Pend Oreille, Idaho, 1951-1974.

Year	Catch	Drawdown cm (ft)		Catch (+5 yrs)
1951	820,000	--		1,093,000
1952	515,000	219.5	7.2	751,000
1953	1,336,000	42.7	1.4	1,197,000
1954	1,240,000	289.6	9.5*	1,162,000
1955	650,000	115.8	3.8	1,039,000
1956	1,093,000	73.2	2.4	992,000
1957	751,000	155.4	5.1	651,000
1958	1,197,000	88.4	2.9	1,049,000
1959	1,162,000	76.2	2.5	1,163,000
1960	1,039,000	91.4	3.0	1,007,000
1961	992,000	170.7	5.6	809,000
1962	651,000	103.6	3.4	710,000
1963	1,049,000	121.9	4.0	618,000
1964	1,163,000	164.6	5.4	483,000
1965	1,007,000	112.8	3.7	655,000
1966	809,000	170.7	5.6	590,000
1967	710,000	61.0	2.0	521,000
1968	618,000	121.9	4.0	329,000
1969	483,000	12.2	0.4	319,000
1970	655,000	42.7	1.4	--
1971	590,000	70.1	2.3	--
1972	521,000	36.6	1.2	--
1973	329,000	0.0	0.0	--
1974	319,000	21.3	0.7	--

*Indicated year when no relationship is shown between drawdown and catch.

Table 8. Estimated minimum catch of kokanee, Kamloops, Dolly Varden and cutthroat trout, Lake Pend Oreille, Idaho, 1951-1974.

Year	Kokanee	Kamloops	Trophy Kamloops	Dolly Varden	Trophy Dolly Varden	Cutthroat
1951	820,486	678		1,775		5,271
1952	514,913	535		2,393		5,850
1953	1,335,881	3,158		5,035		8,201
1954	1,232,916	2,533		3,660		5,322
1955	650,375	2,594		3,811		4,982
1956	1,092,651	3,251		3,288		5,343
1957	751,113	2,938		2,117		5,138
1958	1,197,426	5,286		1,348		5,881
1959	1,161,913	4,906		1,677		3,659
1960	1,039,200	9,626	1,380	2,616	1,491	3,730
1961	991,955	5,355	873	966	568	2,641
1962	650,960	6,556	1,136	1,434	817	2,615
1963	1,049,339	10,323	1,442	1,049	671	3,069
1964	1,162,625	4,942	870	929	502	1,757
1965	1,007,292	4,763	1,141	1,460	672	1,744
1966	808,744	4,978	1,040	1,199	740	2,040
1967	710,312	3,349	767	657	512	788
1968	618,405	4,169	832	624	387	782
1969	483,292	3,297	889	862	588	954
1970	654,848	4,419	1,105	640	493	1,256
1971	590,058	4,462	892	967	532	965
1972	521,048	3,384	880	928	504	1,114
1973	328,739	4,422	663	751	503	973
1974	319,286	4,337	737	847	466	500

Table 9. Average lengths and weights of trophy Kamloops rainbow and Dolly Varden, Pend Oreille Lake, Idaho, 1960-1974.

Year	No. of Kamloops	Average length cm (in)	Average weight kg (lb)	No. of Dolly Varden	Average length cm (in)	Average weight kg (lb)
1960	89	66.0 (26.0)	--	112	55.1 (21.7)	--
1961	69	65.8 (25.9)	--	48	54.9 (21.6)	--
1962	85	64.5 (25.4)	--	59	54.4 (21.4)	--
1963	124	58.7 (23.1)	--	48	57.9 (22.8)	--
1964	81	67.3 (26.5)	--	53	59.4 (23.4)	--
1965	82	66.0 (26.0)	--	63	56.4 (22.2)	--
1966	87	65.3 (25.7)	--	60	54.9 (21.6)	--
1967	76	61.0 (24.0)	--	47	51.1 (20.1)	--
1968	70	65.6 (25.8)	--	43	53.8 (21.2)	--
1969	78	65.3 (25.7)	--	70	55.6 (21.9)	--
1970	92	65.0 (25.6)	--	55	56.1 (22.1)	--
1971	249	67.1 (26.4)	--	136	55.9 (22.0)	--
1972	237	69.3 (27.3)	4.9 (10.9)	138	51.8 (20.4)	2.7 (5.0)
1973	137	70.4 (27.7)	5.4 (11.8)	131	55.4 (21.8)	2.6 (5.8)
1974	216	67.3 (26.5)	4.7 (10.3)	168	54.1 (21.3)	2.1 (4.6)
Average (weighted)		66.3 (26.1)	4.9 (10.9)		54.9 (21.6)	2.3 (5.1)

APPENDIX I I

2S

Table 1. Divisional residency of anglers fishing Lake Pend Oreille, Idaho, 1973 and 1974.

		1973	1974
Pacific States			
California		1,014	1,421
Oregon		164	210
Washington		4,619	4,949
	Subtotal	5,797	6,580
	Percent	53.7	50.1
Mountain States			
Arizona		100	153
Colorado		19	52
Idaho		4,559	5,859
Montana		50	125
New Mexico		6	12
Nevada		39	94
Utah		24	39
Wyoming		2	3
	Subtotal	4,799	6,337
	Percent	44.4	48.3
West North Central States			
Iowa		10	5
Kansas		6	6
Minnesota		9	7
Missouri		3	3
Nebraska		7	44
North Dakota		-	18
South Dakota		7	-
	Subtotal	42	83
	Percent	0.4	0.6
East North Central States			
Indiana		2	2
Illinois		6	4
Michigan		13	10
Ohio		8	11
Wisconsin		10	4
	Subtotal	39	31
	Percent	0.4	0.3
New England States			
Connecticut		4	2
New Hampshire		-	1
Rhode Island		2	-
	Subtotal	6	3
	Percent	0.1	0.0

Table 1. Divisional residency of anglers fishing Lake Pend Oreille, Idaho, 1973 and 1974 (continued).

		1973	1974
Middle Atlantic States			
New Jersey		6	1
New York		-	2
Pennsylvania		-	3
	Subtotal	6	6
	Percent	0.1	0.1
South Atlantic States			
Florida		19	16
Virginia		-	1
West Virginia		1	-
	Subtotal	20	17
	Percent	0.2	0.1
East South Central States			
Alabama		-	1
Kentucky		2	1
Mississippi		1	-
	Subtotal	3	2
	Percent	0.0	0.0
West South Central States			
Arkansas		-	1
Louisiana		-	2
Oklahoma		31	5
Texas		24	23
	Subtotal	55	31
	Percent	0.5	0.3
Non-Continental States			
Alaska		2	-
Hawaii		2	2
	Subtotal	4	2
	Percent	0.0	0.0
Foreign Countries			
Canada		19	25
Japan		1	-
Mexico		6	4
Norway		1	-
	Subtotal	27	29
	Percent	0.2	0.2
	Total	10,798	13,121

Table 2. County residency of Idaho anglers fishing Lake Pend Oreille, Idaho, 1973 and 1974.

		1973	1974
Region 1--Panhandle			
Local Counties			
Bonner		1,625	2,096
Kootenai		1,832	2,233
	Subtotal	3,457	4,329
	Percent	75.8	73.9
Other Counties			
Benewah		15	24
Boundary		67	104
Shoshone		321	458
	Subtotal	403	586
	Percent	8.8	10.0
Region 2--Clearwater			
Clearwater		20	24
Idaho		1	9
Latah		223	301
Lewis		5	12
Nez Perce		369	495
	Subtotal	618	841
	Percent	13.6	14.3
Region 3--Western			
Ada		36	25
Boise		-	10
Canyon		4	13
Elmore		-	1
Payette		-	2
Valley		-	5
Washington		-	5
	Subtotal	40	61
	Percent	0.9	1.0
Region 4--Magic Valley			
Blaine		2	-
Camas		2	-
Cassia		10	7
Gooding		3	-
Jerome		-	2
Lincoln		-	2
Minidoka		-	10
Twin Falls		10	-
	Subtotal	27	21
	Percent	0.6	0.4

Table 2. County residency of Idaho anglers fishing Lake Pend Oreille, Idaho, 1973 and 1974 (continued).

		1973	1974
Region 5--Eastern			
Bannock		1	7
Bingham		-	2
Bonneville		9	8
Madison		2	-
	Subtotal	12	17
	Percent	0.3	0.3
Region 6-- Upper Snake			
Butte		-	4
Lemhi		2	-
	Subtotal	2	4
	Percent	0.0	0.1
	Total	4,559	5,859

JOB PERFORMANCE REPORT

State of Idaho Name: LAKE AND RESERVOIR INVESTIGATIONS

Project No. F-53-R-10 Title: Clark Fork River Fishery Investigations

Job No. IV-b

Period Covered: 1 March 1974 to 28 February 1975

ABSTRACT:

In 1974, October anglers fishing Clark Fork River caught an estimated 39 trophy Kamloops, 432 mm (17 in) and larger, and 16 trophy Dolly Varden.

Approximately 80% of the anglers fishing Clark Fork River resided in the Pacific and Mountain states with 20% living in other states. In Idaho, the three northern-most counties contributed nearly 85% of the state's anglers and 39% of all anglers fishing the river.

Author:

Richard A. Irizarry
Senior Fishery Research Biologist

RECOMMENDATIONS:

The creel census and its evaluation should continue on the Clark Fork River.

OBJECTIVES:

To estimate angling pressure and harvest of Kamloops and Dolly Varden on the Clark Fork River fishery.

To determine size and age composition of fish harvested.

To evaluate the fishery and its relationship to the Lake Pend Oreille fishery for Kamloops and Dolly Varden and recommend fisheries management procedures.

TECHNIQUES USED:

During 1974, I used a random stratified creel census on Clark Fork River to estimate the total catch of trophy Kamloops and Dolly Varden.

A census clerk interviewed anglers at a check station near the town of Clark Fork and at Johnson Creek access area. He operated the station 2 week-days and 2 weekend days per week during the fishery.

FINDINGS:

Trophy trout catch

The census clerk interviewed 357 anglers who fished 1,590 hours to catch 22 trophy Kamloops and 11 trophy Dolly Varden (Table 1).

Anglers fished an estimated 2,736 hours during 608 man-days to catch 39 trophy Kamloops and 16 trophy Dolly Varden (Table 2).

Residents comprised 460 of the anglers. They expended 53% of the effort to catch 55% of the combined trophy fish harvest.

Nonresidents comprised 54% of the anglers and expended 47% of the effort to catch 45% of the combined trophy fish harvest.

River vs lake trophy fishery

Interviewed anglers on the river averaged 72.3 hours per trophy Kamloops caught and 144. 5 hours per Dolly Varden. Anglers on the lake averaged 147.4 hours per trophy Kamloops caught and 92.1 hours per trophy Dolly Varden for a similar time period (4 October to 21 October 1974).

River anglers fished an average of 4.5 hours per day while lake anglers averaged 5.1 hours.

Table 1. Catch data for interviewed anglers seeking "trophy" fish species, Clark Fork River, Idaho, 1974.

License type	No. anglers	Hrs. fished	Fish caught: Kamloops	Dolly Varden
Resident	180	901	12	9
Nonresident	177	689	10	2
Total	357	1,590	22	11

Table 2. Estimated minimum number of angler man-days, hours fished and catch of "trophy" fish species, Clark Fork River, Idaho.

License type	Angler man-days	Hrs. fished	Fish caught: Kamloops	Dolly Varden
Resident	279	1,439	18	12
Nonresident	329	1,297	21	4
Total	608	2,736	39	16

Clark Fork River anglers caught an estimated 39 trophy Kamloops and 16 trophy Dolly Varden between 30 September and 21 October. Lake Pend Oreille anglers caught an estimated 737 trophy Kamloops and 466 trophy Dolly Varden between 4 May and 30 November.

Catch rates for anglers seeking Kamloops on the lake have remained relatively stable since 1960 while the river fishery rates have declined since 1966 (Table 3).

Average size of Kamloops and Dolly Varden taken from the Clark Fork River has remained relatively constant since 1968 (Table 4).

Angler residency

During the creel census, the check station clerk interviewed 309 anglers to determine their home residency (Appendix). Approximately 17% (54) of the anglers came from the Pacific states and 63% (194) resided in the Mountain states with 46% (142) from Idaho alone. About 20% (61) came from other states.

Residents from North Idaho counties comprised 93% (132) of the Idaho anglers. Bonner, Boundary and Kootenai counties produced 85% (121) of the Idaho anglers and 39% of all anglers.

Table 3. Catch data for interviewed anglers seeking trophy Kamloops at Lake Pend Oreille and its tributary Clark Fork River, 1960 to 1974*

Year	Lake Pend Oreille			Clark Fork River		
	Hours	Kamloops	Hrs/fish	Hours	Kamloops	Hrs/fish
1960	4,567	76	60.1		No census	
1961	4,066	64	63.5		No census	
1962	3,357	77	43.6		No census	
1963	4,831	65	74.3		No census	
1964	4,459	68	65.6		No census	
1965	3,849	81	47.5		No census	
1966	4,263	88	48.4	666	59	11.3
1967	4,219	66	63.9	1,519	71	21.4
1968	3,533	58	60.9	2,093	63	33.2
1969	4,106	68	60.4	1,945	48	40.5
1970	5,996	83	72.2	1,975	44	44.9
1971**	16,179	236	68.6	1,511	14	107.9
1972	16,566	234	70.8	1,940	37	52.4
1973	13,391	143	93.6	774	23	33.7
1974	16,571	207	80.1	1,590	22	72.3
Avg.	--	--	68.1	--	--	36.8

*Lake vs. river catch rates should not be compared since the lake census extends for 7 months and the river census between 3 weeks and 2½ months. However, the data suggests the trends of each fishery.

**A more intensive census commenced on Lake Pend Oreille in 1971 and would account for the increase catch data from previous years.

Table 4. Average lengths and weights of trophy Kamloops rainbow and Dolly Varden, Clark Fork River, Idaho, 1967-1974.

Year	No. of Kamloops	Average length cm (in)	Average weight kg (lb)	No. of Dolly Varden	Average length cm (in)	Average weight kg (lb)
1967	113	77.2 (30.4)	7.1 (15.7)	52	63.2 (24.9)	3.0 (6.7)
1968	59	75.7 (29.8)	6.4 (14.1)	89	56.9 (22.4	2.3 (5.1)
1969	49	74.2 (29.2)	--	57	60.2 (23.7)	--
1970	44	78.5 (30.9)	--	101	58.4 (23.0)	--
1971	14	79.2 (31.2)	--	27	56.9 (22.4)	--
1972	28	77.0 (30.3)	6.8 (15.1)	10	65.0 (25.6)	3.5 (7.7)
1973	22	78.5 (30.9)	8.2 (18.1)	6	59.7 (23.5)	3.0 (6.7)
1974	20	79.0 (31.1)	7.4 (16.3)	20	62.0 (24.4)	2.7 (5.9)
Average		77.0 (30.3)	7.1 (15.6)		59.2 (23.3)	2.6 (5.7)

APPENDIX

Table 1. Divisional residency of anglers fishing Clark Fork River, Idaho, 1973 and 1974.

		1973	1974
Pacific States			
California		25	14
Oregon		11	8
Washington		17	32
	Subtotal	53	54
	Percent	26.1	17.5
Mountain States			
Colorado		5	-
Idaho		99	142
Montana		17	46
New Mexico		3	2
Utah		-	4
	Subtotal	124	194
	Percent	61.1	62.8
West North Central States			
Minnesota		-	1
Nebraska		7	-
South Dakota		4	7
	Subtotal	11	8
	Percent	5.4	2.6
Middle Atlantic States			
New York		-	3
Pennsylvania		-	14
	Subtotal	-	17
	Percent	0.0	5.5
South Atlantic States			
Florida		10	16
	Subtotal	10	16
	Percent	4.9	5.1
West South Central States			
Texas		5	12
	Subtotal	5	12
	Percent	2.5	3.9
Foreign Countries			
Canada		-	8
	Subtotal	-	8
	Percent	0.0	2.6
	Total	203	309

Table 2. County residency of Idaho anglers fishing Clark Fork River, Idaho, 1973 and 1974.

		1973	1974
Region 1--Panhandle			
Bonner		46	87
Boundary		21	17
Kootenai		9	17
	Subtotal	76	121
	Percent	76.8	85.2
Region 2--Clearwater			
Clearwater		-	1
Latah		-	10
Lewis		2	-
Nez Perce		2	-
	Subtotal	4	11
	Percent	4.0	7.8
Region 3--Western			
Ada		-	1
Canyon		4	1
Valley		2	5
	Subtotal	6	7
	Percent	6.1	4.9
Region 5--Eastern			
Bear Lake		2	-
Bingham		2	-
Bonneville		9	3
	Subtotal	13	3
	Percent	13.1	2.1
	Total	99	142

JOB PERFORMANCE REPORT

State of Idaho Name: LAKE AND RESERVOIR INVESTIGATIONS

Project No. F-53-R-10 Title: Kokanee Spawning Trends

Job No. IV-c

Period Covered: 1 March 1974 to 28 February 1975

ABSTRACT:

Spawning escapement from both early and late-run kokanee was assessed in Lake Pend Oreille and its tributaries during the 1974-75 spawning season.

Early-run kokanee began spawning in Trestle Creek on 14 September 1974 and continued through 6 October when most spawning activity terminated. Trestle Creek supported fewer kokanee in 1974 (maximum single count - 217) than in either 1973 (maximum single count - 1,076) or 1972 (maximum single count - 5,000).

More late-run kokanee were observed spawning in the tributary streams of Lake Pend Oreille during the 1974-75 spawning season than were seen in the tributaries during the 1973-74 season but fewer kokanee were observed spawning on the shorelines of the lake in 1974 than in 1973. Shoreline spawners were first observed 15 November 1974 in Bayview and peaked with 3,588 kokanee counted on 6 December. Granite Creek supported the largest run of tributary kokanee spawners during the 1974-75 spawning season with a maximum single count of 17,869 kokanee counted 15 December 1974. An estimated 40, 000+ kokanee entered the Granite Creek drainage to spawn.

Overall, by comparing maximum single counts of late-run kokanee made during the 1974-75 and 1973-74 spawning seasons, there was a slight increase in the number of spawners observed from 1974-75 to 1973-74 but almost a 3 to 1 increase from both years over the number of spawners observed in 1972-73.

The water level of Lake Pend Oreille stabilized 15 November 1974 at 2,051.6 ft and was drawn only 0.6 ft below that level throughout the 1974-75 kokanee spawning and incubation period.

Author:

Bert Bowler
Senior Fishery Research Biologist

RECOMMENDATIONS:

1. Continue monitoring kokanee escapement annually in Lake Pend Oreille and its tributaries by making counts every 5 days or as close to a 5-day interval as possible.

2. Continue collecting otoliths from spawning kokanee *throughout* the drainage for age and growth measurements.

3. Continue counting spawning kokanee through the weir at the mouth of Sullivan Springs Creek.

4. Renew and/or clean the spawning gravels in Spring Creek and Sullivan Springs.

OBJECTIVES:

To develop methodology and arrive at an index of relative abundance of kokanee spawners for year-to-year trend comparisons.

To record the location and abundance of kokanee spawners and to as-certain if subpopulations exist.

To document the duration and peak time of kokanee spawning.

To relate reservoir water levels to lakeshore kokanee spawning.

To evaluate major changes in lake or stream areas used for kokanee spawning in 1974 as compared to those used during the 1950's.

To evaluate suitability of beach and stream spawning materials and relate percentage of fines to use and egg mortalities.

TECHNIQUES USED:

We counted or estimated numbers of kokanee utilizing spawning areas of Lake Pend Oreille and its tributaries throughout the 1974-75 spawning season. Counts along the shorelines were made from an airplane, boat and by walking. We also used a boat with a glass observation window to note spawning activity in deep water. Tributary counts were made by walking each tributary stream from its mouth to the upper extent of kokanee spawners except for the Clark Fork River. We made two counts (24 November and 15 December) in the Clark Fork River from Cabinet Gorge Dam to its mouth by drifting in two small boats, one on each side of the river. The November count was made when Washington Water Power Company reduced the flow at Cabinet Gorge Dam to 3,000 cfs and the December count was made during a zero flow release from the dam. Kokanee were enumerated individually when possible but mostly they were counted in numbers of 10's and 100's because of their density.

An attempt was made to make each count at a 5-day interval except for the Granite Creek drainage we attempted to count daily. Because of limited personnel and poor observation conditions, we could not maintain the 5-day schedule in all areas of the lake. The U. S. Army Crops of Engineers aided the survey by making kokanee counts from a boat in the north end of the lake.

We refurbished the old weir at the mouth of Sullivan Springs Creek and enumerated mature kokanee through the weir daily during the spawning season. We also collected 10 gravel samples from the entire length of Sullivan Springs Creek. The Corps of Engineers sieved the gravel samples at their soil laboratory in Libby, Montana for assessment of the percentage of fines in the spawning gravels.

FINDINGS: Early-run

kokanee

Trestle Creek, the only known recipient of early spawning kokanee in the immediate Pend Oreille Lake drainage, supported fewer kokanee in 1974 than in either 1973 or 1972 (Fig. 1). We first observed kokanee spawning in Trestle Creek 14 September 1974 and by 6 October spawning was mostly completed. In late September, when the Tun peaked, we counted 217 kokanee in the drainage (Fig. 1).

Late-run kokanee

More late spawning kokanee were observed spawning in the tributary streams of Lake Pend Oreille during the 1974-75 spawning season than were seen in the tributaries during the 1973-74 season, but fewer kokanee were observed spawning on the shorelines of the lake in 1974 than in 1973.

Shoreline spawners were first observed 1S November, at Bayview. The peak number of kokanee occurred at Bayview on 6 December with 3,588 kokanee counted (Table 1). We observed fewer kokanee during the 1974-75 spawning season at Bayview than were seen in 1973-74 but more than were observed in 1972-73 (Fig. 2). Other shoreline areas received few spawners (Table 1).

Tributary spawners were first observed 8 November entering North Gold and Granite creeks. We observed a few less kokanee spawners in North and South Gold creeks during the 1974-75 spawning season than were seen during the 1973-74 season but more than we saw in 1972-73 (Fig. 3; Table 2). More spawners were observed in Spring Creek during the 1974-75 spawning season than were seen during either the 1973-74 or 1972-73 season (Fig. 4; Table 2). The kokanee run into Lightning Creek peaked 2 December with 2,350 fish (Fig. 4). Cedar, Twin and Trestle creeks supported small runs of late spawning kokanee during the 1974-75 season (Table 2). We made two kokanee counts in the Clark Fork River on 24 November and 15 December. The first count yielded 785 spawners when the flow at Cabinet Gorge Dam was reduced to 3,000 cfs and the second count yielded 6,180 with a zero flow at the dam (Table 2). We also observed a small run of kokanee in Garfield Creek where none were seen in 1973 (Table 2).

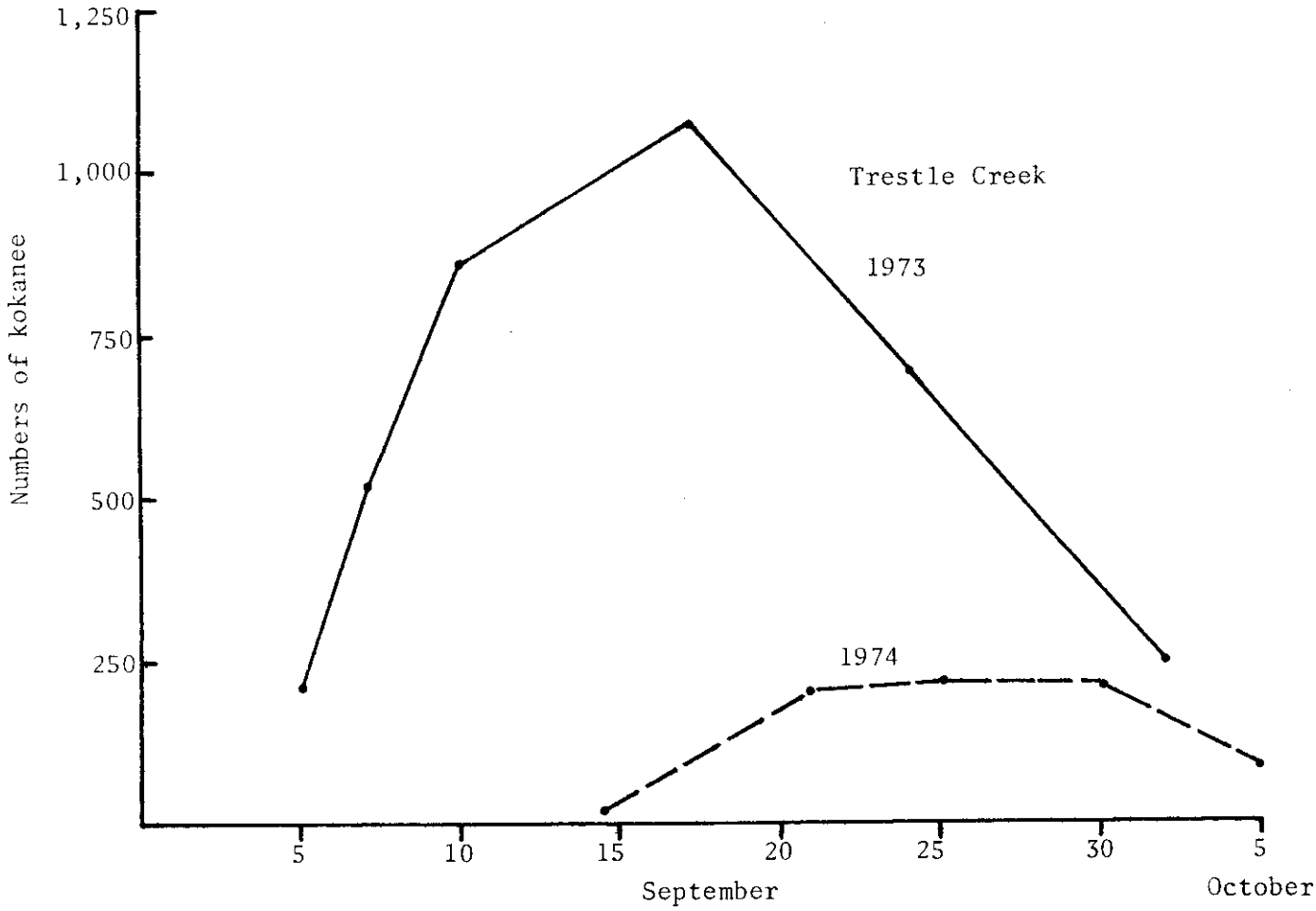

Figure 1. Numbers of early-run kokanee counted in Trestle Creek during the 1973 and 1974 spawning seasons in Lake Pend Oreille.

Table 1. Number of spawning kokanee (late-run) counted on the shoreline areas of Lake Pend Oreille, 1974.

Shoreline	November		December							
	21	26	1	6	9	11	16	21	25	31
Bayview beach (entire)	3,552	1,752	2,043	3,588		2,135	2,700	1,808	1,249	177
Breakdown:										
Bubb's	200	100	50					8	4	
Wheel Inn	250	300	300	300		100	300	50	60	10
J. D.'s		12	8							
Boileaus	2,000	500	300	900		500	700	600	500	100
Bayview Resort	400	300	1,000	1,700		1,000	900	500	200	15
Navy Yards	660	500	300	500		200	600	400	375	20
Private Docks	40	15	40	85		85	60	70	50	20
MacDonalds	2	25	45	100		225	100	150	35	8
Redman's				3		25	40	30	25	4
Idlewild Bay			25							
Lakeview							18			
Ellisport Bay		925		500			100			
Hope					50					
Jeb and Margarets		500			750		750			
Chris and Mays		875			1,000		1,500			
Fishermen Island				75						
Anderson Point		50								
Garfield Bay	20									

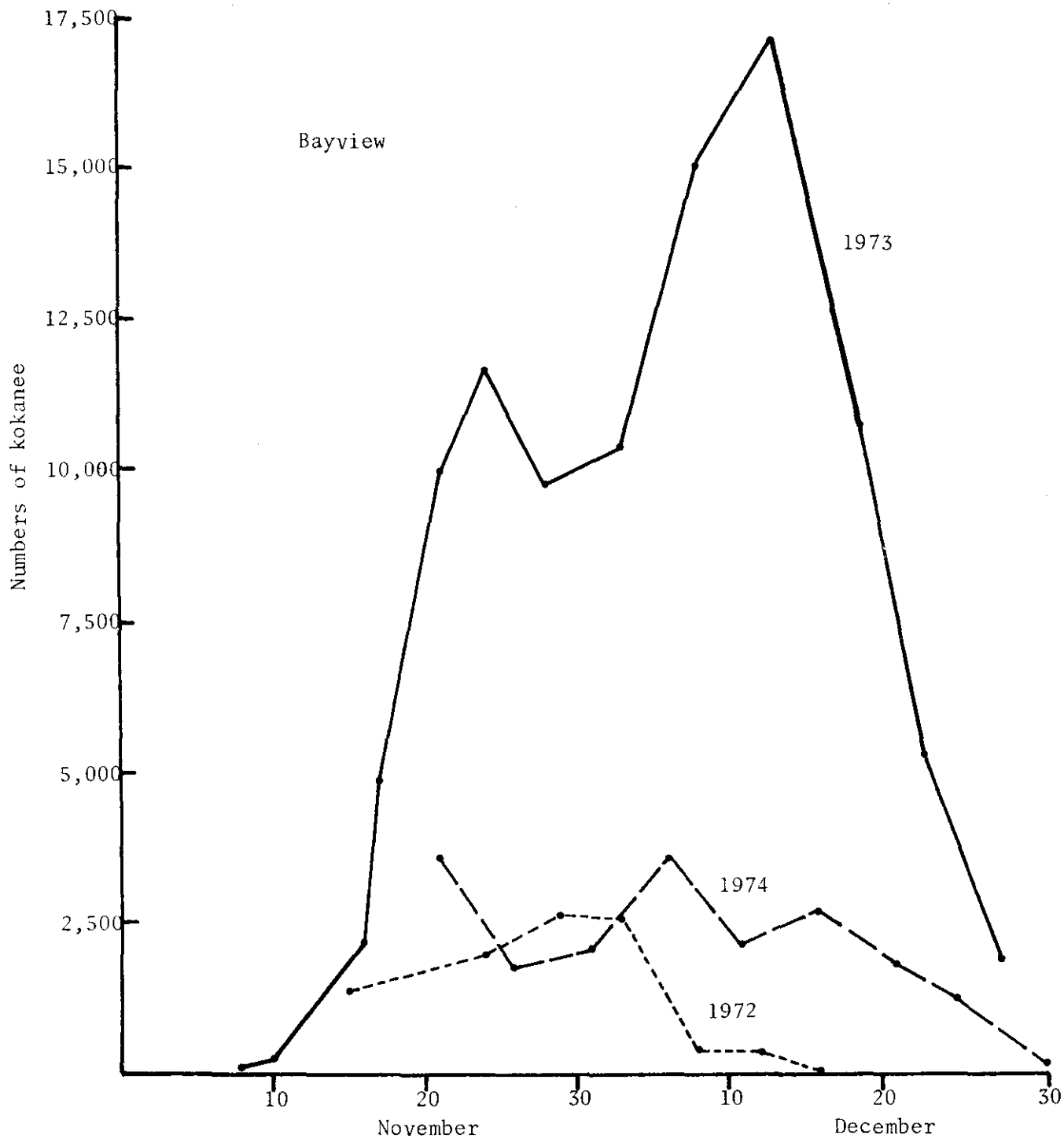

Figure 2. Numbers of lakeshore spawning kokanee counted in the Bayview area during the 1972-73, 1973-74 and 1974-75 late spawning seasons in Lake Pend Oreille.

Table 2. Numbers of spawning kokanee (late-run) counted in the tributaries of Lake Pend Oreille, 1974-75.

Stream	November				December								
	16	22	24	25	2	4	6	10	12	15	16	18	23
South Gold Creek	372			975	960		1,050		1,012		1,018		
North Gold Creek	728			1,068	929		1,030		964		903		
Cedar Creek	4			44	34		36		18		9		
Johnson Creek								1					
Twin Creek				65	105			135				65	35
Clark Fork River			785*							6,180**			
Lightning Creek				50	2,350			1,780				1,520	1,030
Spring Creek				30	3,925			8,490				9,450	8,400
West Fork Trestle Creek				200		350		460			505		340
Trestle Creek				575		670		705			580		195
Garfield Creek		30						25					

* Clark Fork River flow at Cabinet Gorge Dam 3,000 cfs.
** Clark Fork River flow at Dabinet Gorge Dam 0 cfs.

Table 2. Numbers of spawning kokanee (late-run) counted in the tributaries of Lake Pend Oreille, 1974-75 (continued).

	December 31	January 3
South Gold Creek		
North Gold Creek		
Cedar Creek		
Johnson Creek		
Twin Creek		
Clark Fork River		
Lightning Creek		125
Spring Creek		2,360
West Fork Trestle Creek	95	
Trestle Creek	55	
Garfield Creek		

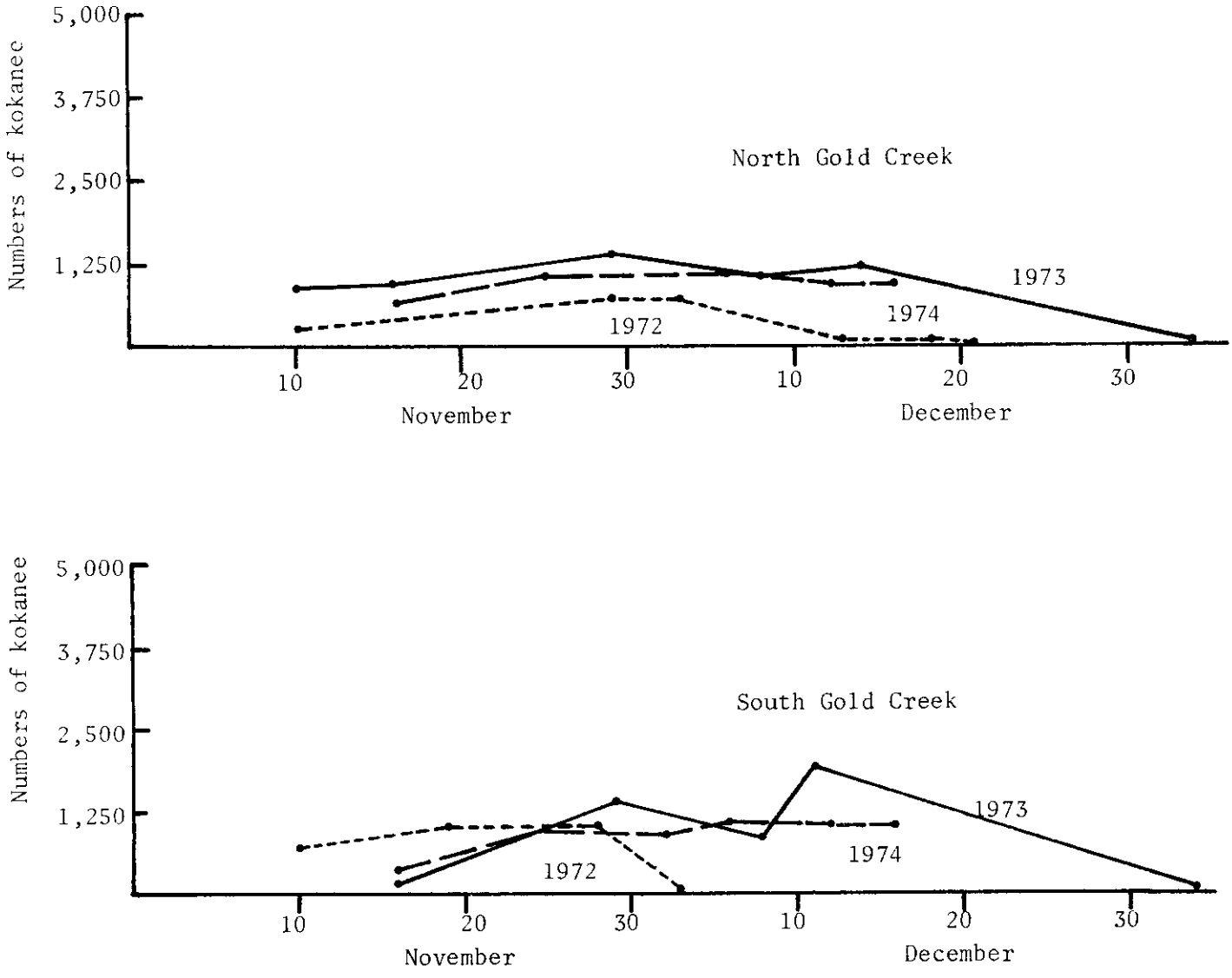

Figure 3. Numbers of spawning kokanee counted in North and South Gold creeks during the 1972-73, 1973-74 and 1974-75 late spawning seasons in Lake Pend Oreille.

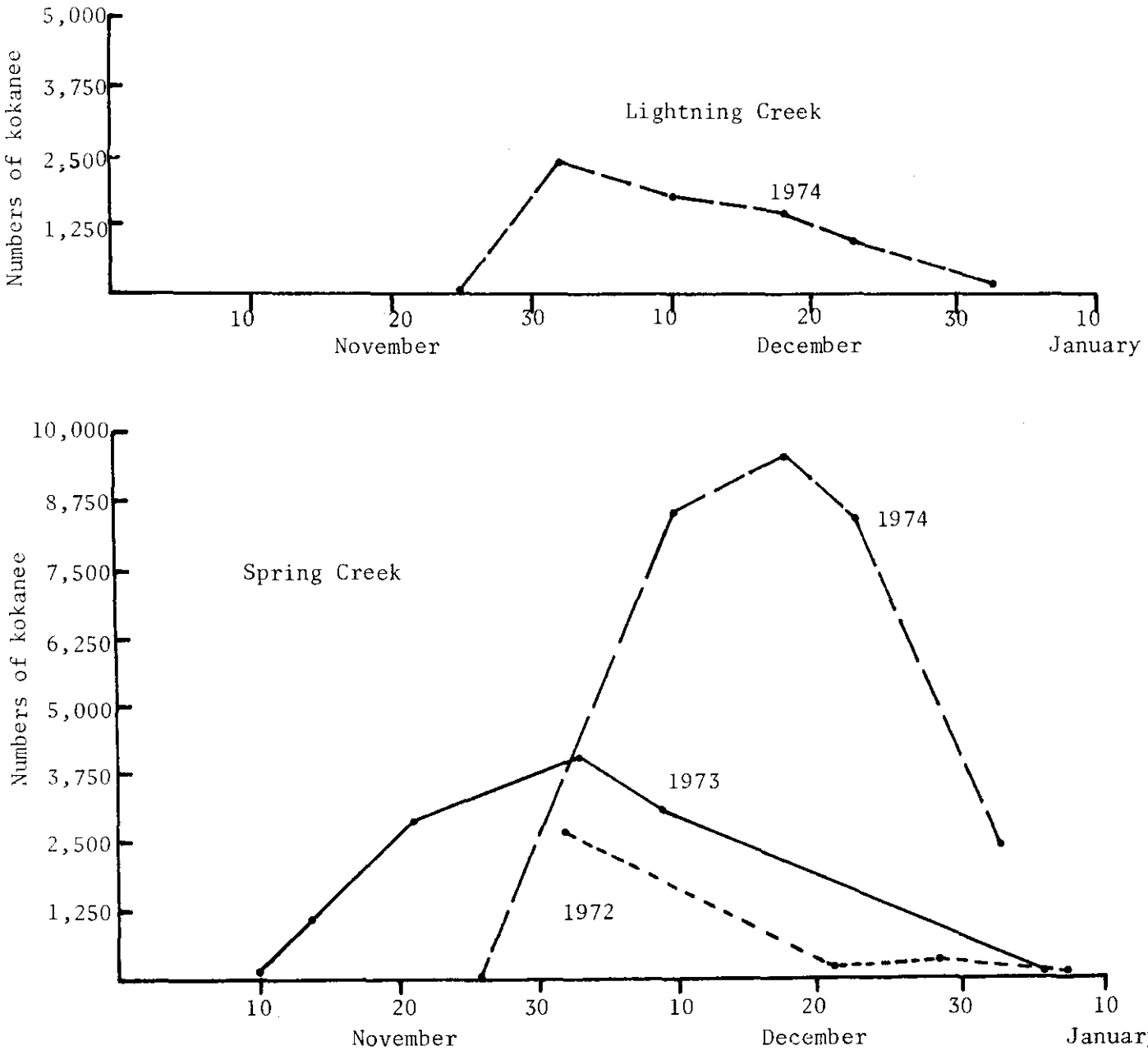

Figure 4. Numbers of spawning kokanee counted in Lightning and Spring creeks during the 1972-73, 1973-74 and 1974-75 late spawning seasons in Lake Pend Oreille.

We observed more spawning kokanee in Granite Creek during the 1974-75 spawning season than in any other tributary in the lake. The run far exceeded either of the spawning runs in 1973-74 or 1972-73 (Fig. 5). The maximum single count was 17,869 kokanee made on 15 December 1971 (Fig. 51. We counted a total of 13,519 kokanee through the weir at the mouth of Sullivan Springs Creek from 10 November to 17 December 1974 (Table 5). This represents a minimum count because of problems with holes in the weir and trap that allowed kokanee to pass without counting them. Kokanee actively spawned in upper Granite Creek (the portion of Granite Creek above the mouth of Sullivan Springs Creek) during the 1974-75 spawning season (Table 3). Mid-morning water temperatures in Sullivan Springs Creek maintained 7 C (45 F) while the temperatures in lower Granite Creek (below the mouth of Sullivan Springs Creek) averaged 6 C (43 F). The mid-morning water temperatures in upper Granite Creek ranged from 4 C (39 F) to 6 C (43 F), averaging 5 C (41 F), from 9 November to 17 December 1974 (Table 3).

Throughout the entire 1974-75 spawning season, I would estimate that approximately 40,000+ kokanee entered the Granite Creek drainage to spawn.

Lake water levels

The level of Lake Pend Oreille measured 2,051.6 ft on 15 November 1974. On 2 December, the lake was drawn to 2,051.0 ft. The 0.6 ft fluctuation (+ 0.6 ft is about as close to a stable lake level as the Corps can maintain) probably had minimal influence upon the incubation of kokanee embryos buried in the shoreline gravels.

Gravel quality

Gibson (1973) found that spawning gravels from both tributaries and shoreline areas of Lake Pend Oreille contained a high percentage of sand and fines suggesting that embryo survival may be marginal in many areas of the lake. The gravel samples taken from Sullivan Springs Creek in 1974 verify Gibbon's earlier findings. The sieve analysis yielded an average of 29.9% (by volume) of each of the samples passing a 1/4 inch sieve and 13.8% (by volume) of each of the samples passing a #20 (.833 mm) sieve (Table 4). Values approaching 30% (percentage by volume of gravel sample passing a 1/4 inch sieve) and 15% (percentage by volume of gravel sample passing a #20, .833 mm, sieve) indicate that permeability of the gravel is low increasing embryo mortality (McNeil and Ahnell 1964; Bjornn 1973).

Comparing kokanee spawning escapement in 1974 with spawning escapement in 1973, 1972 and in the 1950's

I compared maximum single counts of kokanee collected throughout the 1974-75 spawning season with the same counts made during the 1973-74 spawning season and found a slight increase in the number of kokanee spawners observed from 1974-75 to 1973-74 (Table 5). Both the 1974-75 and 1973-74 seasons showed almost a 3 to 1 increase over the number of spawners observed in 1972-73 (Table 5).

It is difficult to compare spawning escapement trends in the 1950's with that of present trends because much of the early data is spread over several

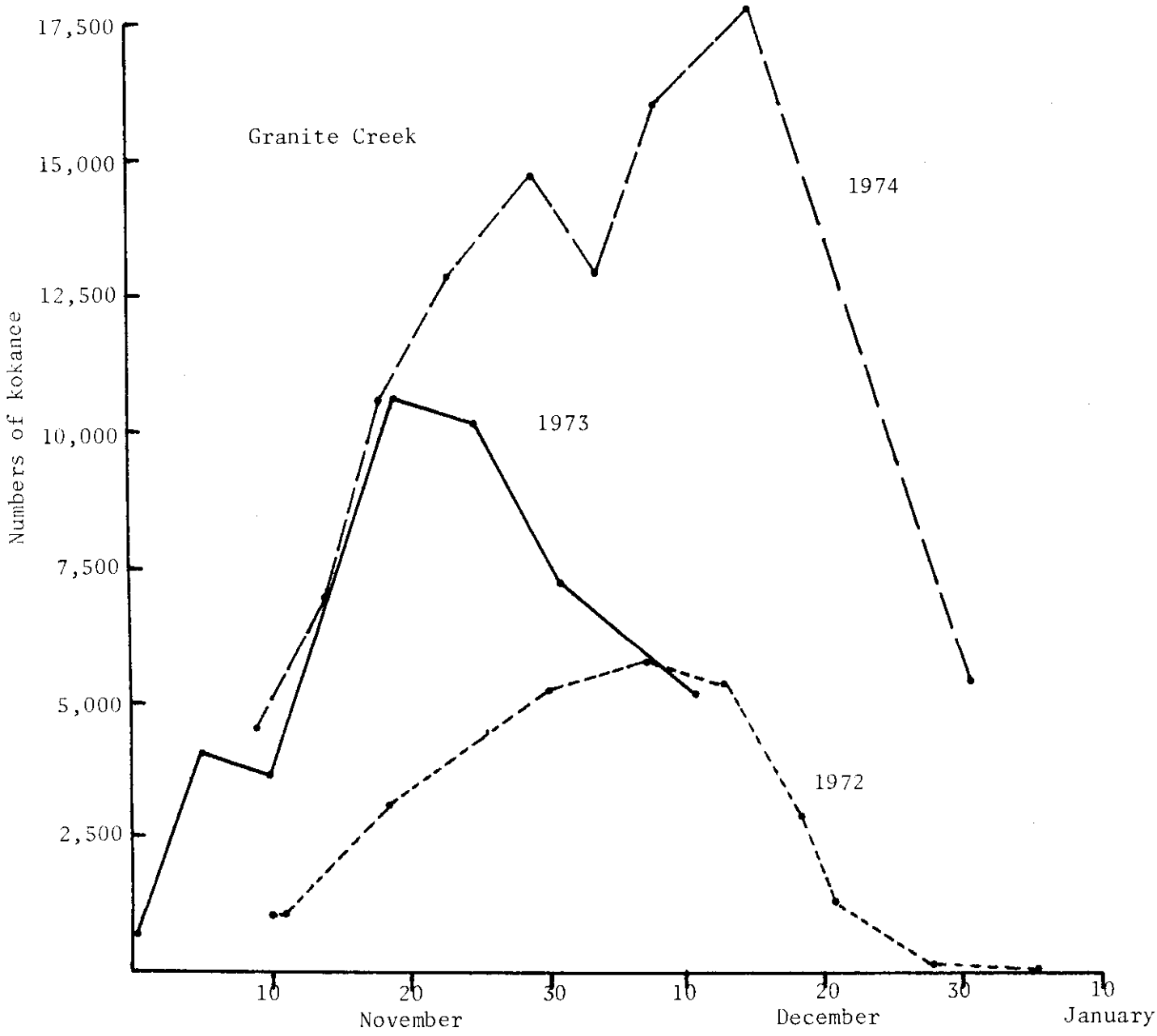

Figure 5. Numbers of spawning kokanee counted in Granite Creek (including Sullivan Springs) during the 1972-73, 1973-74 and 1974-75 late spawning seasons in Lake Pend Oreille.

Table 3. Weir counts of kokanee entering Sullivan Springs Creek and foot survey estimates of upper (above the mouth of Sullivan Springs) and lower Granite Creek taken during the 1974-75 spawning season. Water temperatures were taken during mid-morning.

Date	Weir count	Water temp °C (°F)	Lower Granite Creek	Water temp °C (°F)	Upper Granite Creek	Water temp °C (°F)
November						
9		7 (45)	4,500	6.5 (44)		6 (43)
10	2,667	7 (45)	4,260	6.5 (44)	74	6 (43)
11	56	7 (45)	2,784	6.5 (44)	246	5.5 (42)
12	160	7 (45)	2,857	7 (45)	447	6 (43)
13	293	7 (45)	3,273	6.5 (44)	776	5.5 (42)
14	296	7 (45)	2,958	6.5 (44)	826	5.5 (42)
15	301	7 (45)	3,319	6.5 (44)	930	5.5 (42)
16	138	7 (45)	2,708	6.5 (44)	1,220	5 (41)
17	1,141	7 (45)	3,077	6.5 (44)	1,362	5.5 (42)
18	2,315	7 (45)	3,750	6.5 (44)	1,876	5.5 (42)
19	1,031					
21	72					
23		7 (45)	1,850	6 (43)	2,500	5 (41)
25	4	7 (45)	2,485	6 (43)	3,911	5.5 (42)
26	2	7 (45)	2,233	5.5 (42)	3,853	4.5 (40)
27	11	7 (45)	2,090	5.5 (42)	3,235	4.5 (40)
29	5	7 (45)	2,204	5.5 (42)	3,976	4 (39)
30	24	7 (45)				
December						
1	10	7 (45)				
2	72	7 (45)	2,437	5.5 (42)	3,908	4 (39)
3	125	7 (45)	2,996	6 (43)	3,874	5 (41)
4	303	7 (45)	3,053	6 (43)	4,300	5 (41)
5	1,168	7 (45)	3,698	6 (43)	4,805	5 (41)
6	470	7 (45)	3,715	6 (43)	4,529	5 (41)
7	215	7 (45)	3,861	5.5 (42)	4,622	4 (39)
8	504	7 (45)	3,759	5.5 (42)	4,838	4 (39)
9	298	7 (45)	4,426	5.5 (42)		

Table 3. Weir counts of kokanee entering Sullivan Springs Creek and foot survey estimates of upper (above the mouth of Sullivan Springs) and lower Granite Creek taken during the 1974-75 spawning season. Water temperatures were taken during mid-morning (continued).

Date	Weir count	Water temp °C (°F)	Lower Granite Creek	Water temp °C (°F)	Upper Granite Creek	Water temp °C (°F)
December (cont'd)						
12	619	7 (45)				
13	235	7 (45)				
15	280	7 (45)	3,453	5.5 (42)	4,404	4 (39)
16	465	7 (45)				
17	269	7 (45)				
31		7 (45)	950		500	
Total	13,549*					

*Total weir count is a minimum estimate because of holes in the weir and trap that allowed kokanee to enter Sullivan Springs without counting them.

Table 4. Summary of the gradation analysis* of spawning gravels collected from Sullivan Springs Creek 7 November 1974.

Sample	Percent (by volume) passing a 1/4 in sieve	Percent (by volume) passing a #20 sieve (.833 mm
1	46.1	30.5
2	28.5	11.4
3	35.0	13.8
4	28.6	13.4
5	37.0	13.8
6	12.1	14.2
7	29.5	14.3
8	31.0	10.1
9	19.8	10.5
10	31.8	6.0
Average	29.9	13.8

*Gradation analysis was done by the Corps of Engineers Soils Laboratory in Libby, Montana.

years and is not consistent from year to year in the same areas. Jeppson (1960) found that during the 1950's kokanee spawned in 27 different shore-line areas with some areas averaging more than 1,000 kokanee annually. Runs of 100,000 kokanee were estimated in the Clark Fork River. Gibson (1973) noted kokanee spawning trends in 1972-73 were considerably lower than those trends found in the 1950's. During the 1974-75 and 1973-74 spawning seasons, kokanee escapement was higher than escapement levels of 1972-73 but still below those levels of the 1950's.

DISCUSSION:

Year class abundance

Unless kokanee are entirely opportunistic spawners, the kokanee spawning observations over the past 3 years would indicate that certain spawning areas are supported by varying degrees of year class abundance. For example, in the 1972-73 spawning season, Bayview received few kokanee spawners but during the 1973-74 season, approximately seven times as many spawners were observed in the area. The spawning run in 1974-75 fell to only a slight increase over the run observed in 1972-73. The kokanee run into Granite Creek in 1974-75 was comparable to those in the 1950's indicating an exceptionally large year class compared to the 1972-73 and 1973-74 spawning years.

Early-run kokanee

Over the past 3 years there has been a steady decline in the numbers of early spawning kokanee observed in Trestle Creek. An attempt has been made to bolster the contribution of early spawning kokanee to the Pend Oreille Lake system by the introduction of 1,775,738 kokanee fry into various tributaries around the lake during the spring of 1974 (Table 6).

Late-run kokanee

Because of the exceptionally large run of late spawning kokanee into Granite Creek in 1974, 785,130 kokanee eggs were taken from the system. The eggs were incubated at the Clark Fork Fish Hatchery with the subsequent fry to be released into the Granite Creek drainage in the spring of 1975.

Methodology

To obtain continued annual trends of kokanee escapement, counts should be made every 5 days or as close to a 5-day schedule as possible especially in areas of high kokanee abundance. For annual comparative purposes, escapement estimates from each of the spawning sites should be graphed with the dates of the respective counts (such as Fig. 1-5). Also annual comparisons of escapement should be made by comparing maximum single kokanee counts collected during the entire spawning season (such as Table 5) from each of the spawning sites.

Table 5. Maximum single (late-run) kokanee counts made during the 1972-73, 1973-74 and 1974-75 spawning season on Lake Pend Oreille and its tributaries.

Area	Maximum single counts 1972-73	1973-74	1974-75
Lakeshore			
Bayview	2,626	17,156	3,588
Farragut	25	0	0
Idlewild Bay	13	0	25
Lakeview	4	200	18
Ellisport Bay and Hope	1	436	975
Trestle Creek Resorts	0	1,000	2,250
Sunnyside	0	25	0
Fisherman Island	0	0	75
Anderson Point	0	0	50
Camp Bay	0	617	0
Garfield Bay	0	400	20
Subtotal	2,669	19,834	7,001
Tributaries			
South Gold Creek	1,030	1,875	1,050
North Gold Creek	744	1,383	1,068
Cedar Creek	0	267	44
Granite Creek	5,733	10,631	17,869
Johnson Creek	0	0	1
Twin Creek	0	0	135
Mosquito Creek	0	503	0
Clark Fork River	539	3,520	6,180
Lightning Creek (lower)	350	500	2,350
Spring Creek	2,610	4,025	9,450
Trestle Creek	1,293	18	1,210
Garfield Creek	0	0	25
Subtotal	12,299	22,722	39,382
Grand total	14,968	42,556	46,383

Table 6. Numbers and locations of fry introductions of early spawning kokanee introduced into the Pend Oreille Lake during the spring of 1974.

Numbers of kokanee fry	Location of introduction	Date
160,560	Pack River (bridge below Colburn)	26 March 1974
220,480	Rapid Lightning Creek (below falls)	21 March 1974
596,100	Grouse Creek (2 sites; first and second bridges)	26 March 1974
87,000	North Fork of Grouse Creek (1 mile upstream from fish ladder)	15 May 1974
144,800	Twin Creek, tributary to Clark Fork River (county road)	9 April 1974
99,840	Johnson Creek (near mouth at access site)	22 March 1974
93,558	Cedar Creek (near mouth)	29 May 1974
374,400	Hoodoo Creek, tributary to Pend Oreille River	19 March 1974
Total 1,776,738		

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Bjornn, Ted. 1973. Survival and emergence of salmon and trout embryos and fry in gravel-sand mixtures. Trans. Amer. Fish. Soc. In press.

Gibson, Harry. 1973. Lake Pend Oreille kokanee spawning trends. Idaho Fish and Game Department, Job Progress Report, F-53-R-8, Job No. IV-c. 29 p.

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McNeil, William J. and Warren H. Ahnell. 1964. Success of pink salmon spawning relative to size of spawning bed materials. U. S. Fish and Wild. Ser., Spec. Sci. Rep. - Fisheries No. 469, 15 p.

JOB PERFORMANCE REPORT

State of Idaho Name: LAKE AND RESERVOIR INVESTIGATIONS

Project No. F-53-R-10 Title: Lake Pend Oreille Limnological Studies

Job No. IV-d

Period Covered: 1 March 1974 to 28 February 1975

ABSTRACT:

Limnological sampling was conducted monthly on Pend Oreille Lake from January-October 1974.

Comparison with previous limnological data indicates that the trophic nature of Pend Oreille Lake has changed little since earlier studies. Limnological trends were similar in 1953 and 1974; however, 1974 was a cooler water year. Primary production may have been slightly higher in 1974. Sur-face pH ranged from 7.7-8.5 in 1974 compared to 7.7-8.3 in 1953. Mean secchi disc transparency at the southern end of the lake was 24.4 ft in 1974 compared to 30.6 ft in 1953.

Total zooplankton standing crops were higher in the south end of the lake (summer mean 42 mg/cubic meter dry weight biomass) than the north end (summer mean 26 mg/cubic meter). Primary and secondary production in the north end of the lake was reduced due to high turbidity and lower flushing time caused by the Clark Fork River inflow.

Changes in the relative abundance of Bosmina and Daphnia appeared to be related to kokanee abundance. The level of kokanee predation may regulate in part the abundance of Daphnia. Bosmina may increase in abundance, due to less competition, in periods of lower Daphnia numbers.

Authors:

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C. Michael Falter
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RECOMMENDATIONS:

1. Kokanee growth rates (all age groups) should be examined separately for north and south end fish, for possible correlation with zooplankton composition and standing crops.

2. Determine (if possible) time of recruitment of young-of-the-year fish and distribution in relation to food supply.

3. Stomach samples should be taken of young-of-the-year fish to determine food selectivity and/or dependence.

4. Continue zooplankton work and limited water quality work to determine trends in interdependence of kokanee populations and lake productivity.

5. Microfossil analysis of sediment cores should be undertaken to determine historical trends in lake productivity and plankton composition.

6. Examine the water quality history of the Clark Fork River to establish inflow quality rate-of-change.

7. Conduct in-depth research on Mysis ecology. Other lakes that received Mysis introductions should be studied for impact on zooplankton community.

8. Place less emphasis on Mysis introductions until we understand their impact on existing zooplankton communities.

OBJECTIVES:

1. To describe selected limnological characteristics of Pend Oreille Lake throughout the year.

2. To describe macrozooplankton composition, distribution, density, and biomass in Pend Oreille Lake.

3. To determine possible relations and interactions between limnological segments of the lake system.

4. To compare results with previous work to ascertain changes in the limnological system which may influence the kokanee population.

TECHNIQUES USED:

The following limnological characteristics were sampled: zooplankton, phytoplankton, oxygen, CO_2, alkalinity, conductivity, ortho-phosphate, nitrate, pH, C^{14} primary productivity, secchi disk transparency, several selected trace elements, and temperature.

Three sampling sites were established and assumed to be representative of the southern, mid-lake, and northern portions of the lake (Figure 1). In addition, sampling was conducted intermittently at the mouth of the Clark Fork River. Sample depths were surface, 3 meters (m), 12 m, 30 m, 46 m, 107 m at all stations, plus an additional 275 m sample at the midlake and southern stations. We sampled monthly from January through October, 1974.

Sampling times were set to correspond as closely as possible with Idaho Fish and Game kokanee sonar work.

Sampling was also conducted cooperatively with the U. S. Geological Survey. The U. S. G. S. supplemented our chemical and physical sampling and ran C^{14} bioassays at the southern and northern stations. The University of Idaho sampled all chemical and physical parameters (excluding C^{14} bioassays) at the mid-lake station.

All phyto- and zooplankton sampling and analyses were done by the University of Idaho.

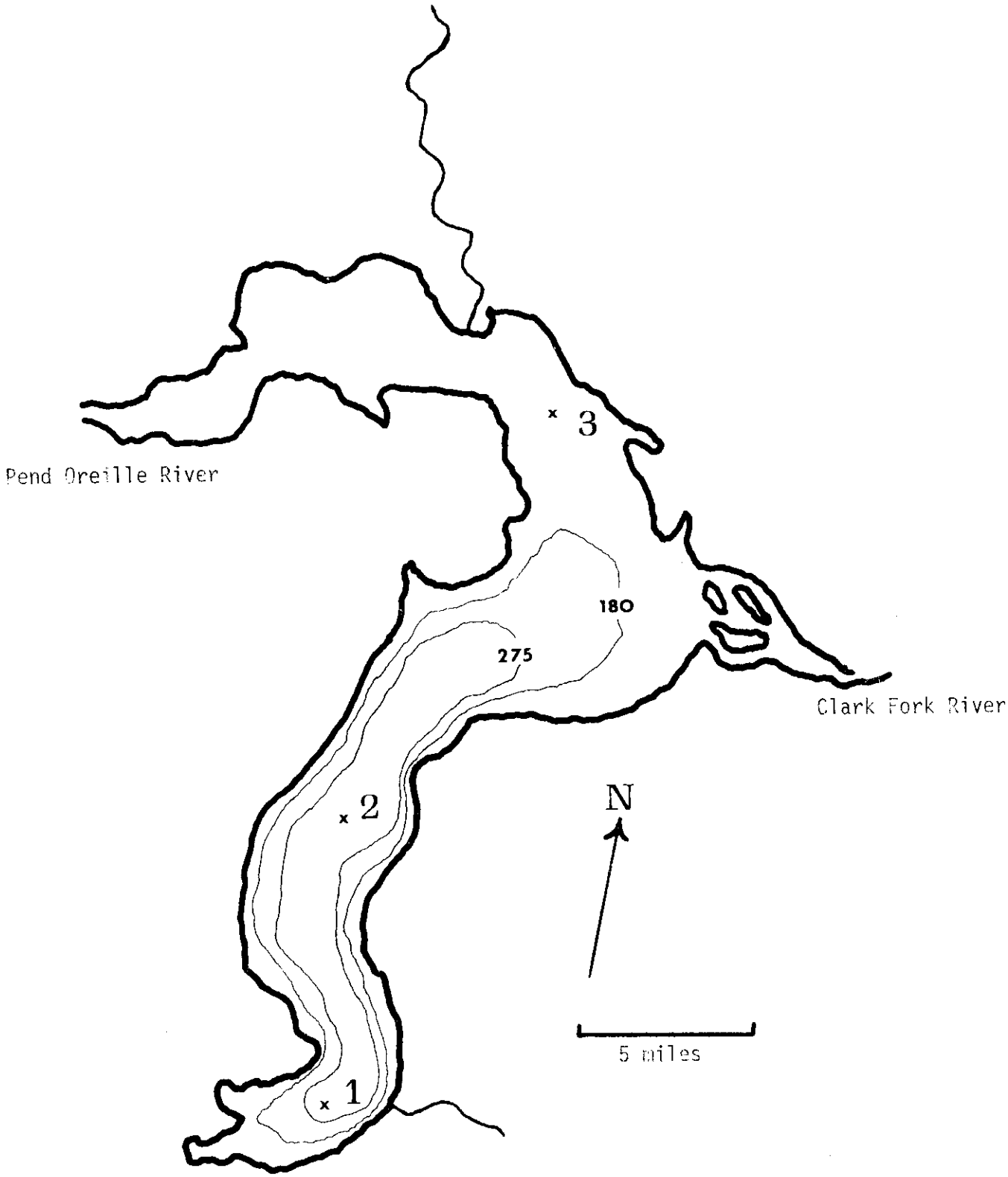

Figure 1. Limnological sampling stations, Pend Oreille Lake, Idaho, 1974.

All analyses were conducted as follows:

Water chemistry and nutrients	-American Public Health Association (1971)
Conductivity	-Labline compensating conductance bridge
pH	-Sargent Welch portable pH meter
Temperature	-900' range bathythermograph
C^{14}bioassay	-U. S. G. S. (1973)
Secchi transparency	-20 cm secchi disk
Phytoplankton	-Wild inverted scope, using a modified sedimentation technique (Lund et al., 1958)

Zooplankton information constitutes the main emphasis in the study. The lake was partitioned into 3 basic sections (Figure 2) corresponding with Fish and Game kokanee census sections and chosen to give the best possible representation of the lake.

Section 1 covers the southern portion of the lake.

Section 2 covers the mid, deepest portion of the lake. It is located south of the immediate Clark Fork River influence.

Section 3 represents the northern portion of the lake and consists of three subsections [3(1), 3(2), 3(3)]. This stratification is necessary to cover the gradient of habitat types in the section. Going from south to north, both wind exposure and depth decrease. At the same time influence from Clark Fork inflow increase.

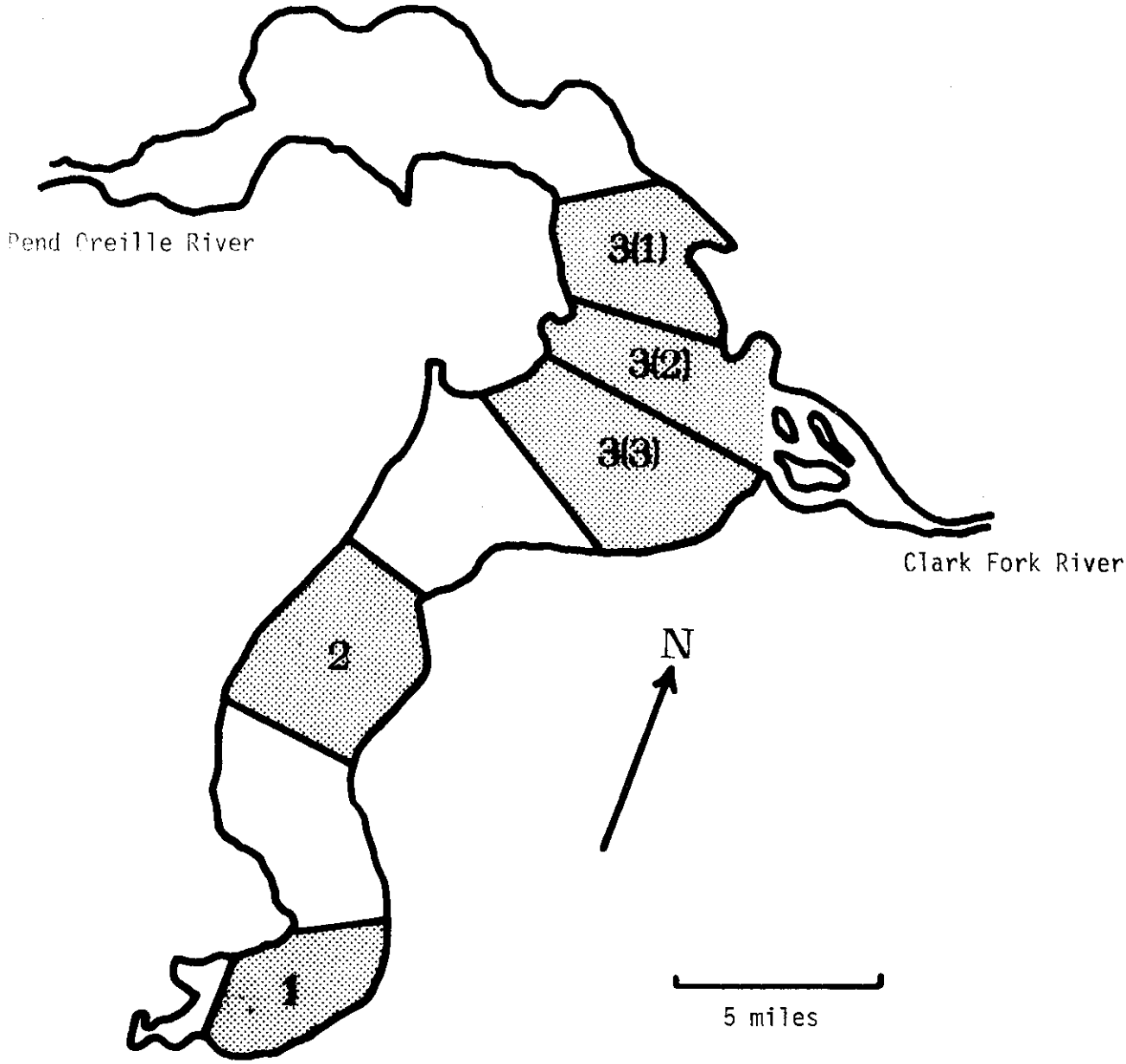

Figure 2. Zooplankton sampling sections, Pend Oreille Lake, Idaho, 1974.

Zooplankton densities varied horizontally and appeared to be dependent upon water mass movement. For these reasons, a number of samples in each area were needed for adequate estimation of zooplankton in that area. Sampling in each section consisted of 3 to 4 permanent stations and several randomly assigned stations.

The number of stations was determined by size, accessibility, and variance of zooplankton densities in each section:

Section 1 had 3 permanent stations and 6 randomly assigned stations. Section 2 had 3 permanent stations and 4 randomly assigned stations. Section 3 had 4 permanent stations and 9 randomly assigned stations.

A calibrated high-speed Miller sampler equipped with a flow meter was used for zooplankton collection. The sampler was fitted with a #10 nylon mesh net. The #10 net was chosen to prevent clogging and subsequent loss of efficiency. It retained only macrozooplankton which comprise essentially 100% of the kokanee diet.

A stepped oblique tow from 46 m (150') was made at each site. The net was towed at a set speed and brought up 1.5 m every 10 seconds. This method was preferred to standard vertical hauls because it reduces variance contributed by zooplankton patchiness. Net avoidance by larger individuals was also lessened. This is especially important for representative sampling of large forms such as Mysis and Leptodora.

In August, during peak zooplankton densities, four replicate tows were made in rapid succession. Statistical evaluation of the samples indicated that the sampling error was low. Mean density was found to be 26.85 plankters/liter with a variance of .57/liter.

Surface temperature and transparency readings (secchi disk) were taken at each sampling point at the initiation of a tow.

During each sampling trip at least one series (3 replications) of vertical tows was made using a #20 Wisconsin net. This is the type

of net and procedure used in earlier Pend Oreille studies. The samples were used to facilitate comparison of earlier data with our own.

Vertical distribution is not a major question in this study. However, the vertical distribution of zooplankton may prove interesting in relation to vertical kokanee distribution. Therefore, a complete diurnal sampling of 7 depths was done in July. Sixteen liter samples were taken from each of 7 depths at 4 hour intervals over a 24-hour period.

At least one night tow was made each month for collection of Mysis specimens and estimation of their densities in the upper waters.

All zooplankton samples were washed from the net into a labelled bottle and preserved with 2% formalin. In the lab, samples were diluted to 100 to 800 ml, depending on the density. Subsamples, (3 to 5 ml each) were taken from the well-mixed sample and placed in a counting tray for identification to species. Mysis and Leptodora required sorting of the entire sample due to their large size and relatively rare occurrence. The counts were then expanded to numbers/liter.

The resulting density estimates were used collectively to estimate the macrozooplankton standing crop for each section.

One representative sample from each section was used for biomass estimation (dry weight).

Our data was compared directly with that reported in 1954. Comparison of zooplankton data required integration of reported densities from staged hauls used in 1952-1954.

FINDINGS:

C^{14} primary productivity (U.S.G.S. data)

C^{14} primary productivity estimates are now completed for June and July, 1974. Primary production was severely depressed in the north end of the lake in June due to high turbidity. Assimilation rate estimates were 16 mg C^{12}/m^2/day in the south (Figure 3). In July assimilation rates were 140 mg C^{12}/m^2/day and 170 mg C^{12}/m^2/day at the north and south stations, respectively. Primary productivity estimates indicate that Pend Oreille is a moderately productive lake.

Phytoplankton

Only preliminary phytoplankton analysis have been completed. Samples have been held for analysis with a new inverted scope which we recently acquired. The dominant forms present in early samples were diatoms including the genera: Melosira, Tabellaria, Fragillaria, Synedra, Cyclotella and Asterionella. Rhizosolenia which was prominent in 1953, has not been found in 1974.

Transparency

Water transparency in 1974, indicated by secchi disk measurements (Figure 4), ranged from a low of .4 m at the northern station (3) on 20 June, to a maximum of 11.5 m at the mid (2) and northern (3) stations on g October. The relatively low transparency at the mid and northern stations during spring months reflect the influence of the Clark Fork River carrying large amounts of silt at flood flows. Low transparencies in June and July were the result of high phytoplankton density in the south end of the lake and a combination of phytoplankton densities and Clark Fork suspended materials at the mid and northern stations. The relative differences observed between the stations represents the range of Clark Fork influence.

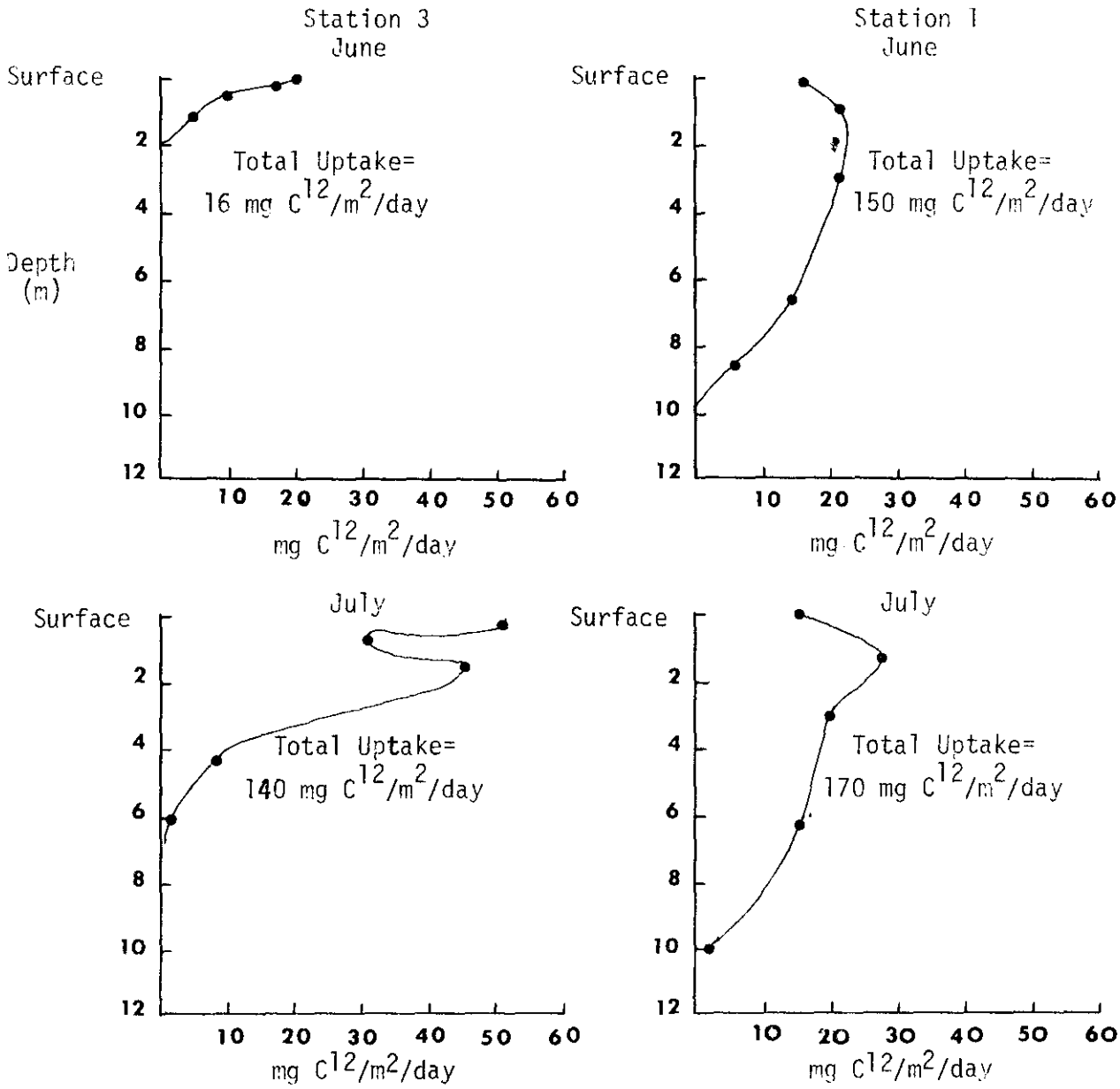

Figure 3. C^{14} primary productivity estimates at two stations, in June and July, Pend Oreille Lake, 1974 (U.S.G.S. Data).

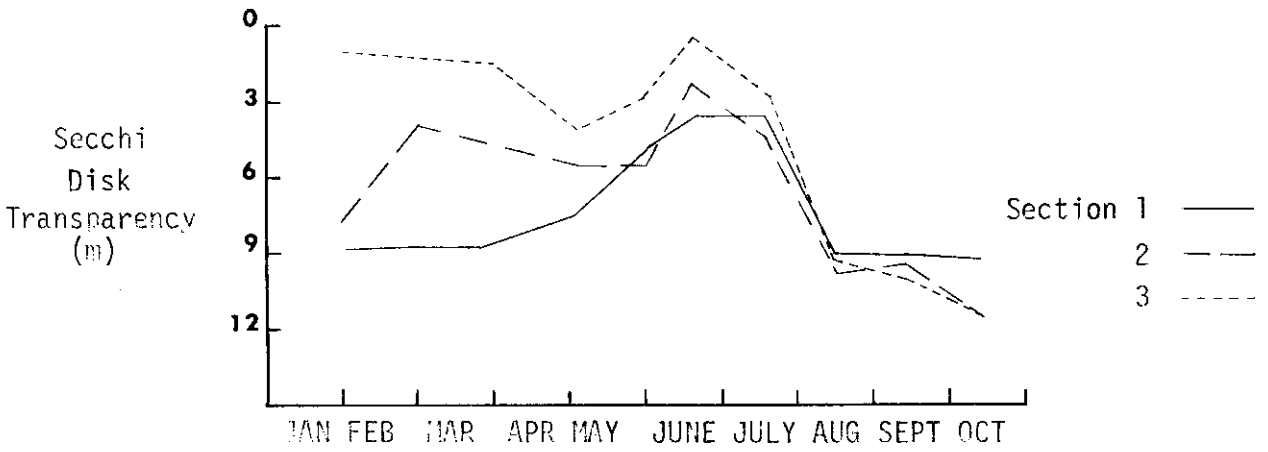

Figure 4. Secchi disk transparency at three stations, Pend Oreille Lake, 1974.

Table 1. Secchi disk transparency (feet) at matching stations 1953 and 1974, Pend Oreille Lake, Idaho.

	Feb 1-3	Mar 1-3	Apr 27-30	May 1-2	June 1-3	June 19-24	July 19-24	Aug 12-15	Sept 3-10	Oct 3-8	Mean
Station 1											
1974	29.5	29	29	25	16	12	12.8	30.4	30	30.6	24.4
1953	47	40	39	26	14	12	20	38	28	42	30.6
Station 2											
1974	26	13	--	18	18	7.5	15.5	32	31	38	--
1953	--	--	--	--	--	12	20	35	40	40	--
Station 3											
1974	3.5	5.5	13	3	9.5	1.4	9.1	31	33.5	38	14.7
1953	9	22	10	12	10	3	21	31	36	34	18.8

Seasonal trends and interstation differences of secchi measurements in 1974 resemble 1953 data (Table 1). However, mean transparency in 1974 (February-October) was approximately 20% lower than in 1953. Higher phytoplankton numbers in 1974 might be indicated. Completion of 1974 phytoplankton analysis and comparison with 1953 data will aid in interpretation.

Temperature

Thermal patterns for Pend Oreille in 1974 were similar to 1952 and 1953, but slightly cooler (Figures 5 and 6). Recorded surface temperatures ranged from 3 C (station 3) in February 1974 to 20 C (station 1) in mid-August. A surface high of 23.9 was noted in 1953. Mean temperatures in 1974 for the upper 46 m (150') ranged from 3.2 C (station 3) in February, to 11.5 C (station 2) in September. Mean temperatures over the same depth in 1953 ranged to 12.8 C. Summer heat budgets were calculated in the same manner as Stross (1954) for comparison of 1952-1953 and 1974 conditions. The maximum summer heat income was 36,271 cal/cm^2 at station 1, 38,405 cal/cm^2 at station 2 and 32,004 cal/cm^2 at station 3. Calculated heat budgets were the same on August 15, 1974 and September 11, 1974 for both southern and northern stations indicating that maximum heat content may have occurred in late August or early September. Stross found the highest heat content of 46,600 cal/cm^2 in early September, 1953, at the south end of the lake. Other heat budgets for 1952 and 1953 approximated budgets for 1974. The higher heat contents noted for the mid- and southern-most stations in 1974 were a result of greater wind mixing action in more exposed areas.

An isotherm graph (Figure 7) shows the seasonal temperature profile for 1974. Early warming began in April and occurred faster in the northern end of the lake as a result of high turbidity from Clark Fork flood waters. The lake continued to warm, forming a thermocline in near surface waters by late June. The thermocline was gradually depressed and warming continued until late August. Cooling had begun by mid-September and the lake was nearly homothermous at 6 C by December.

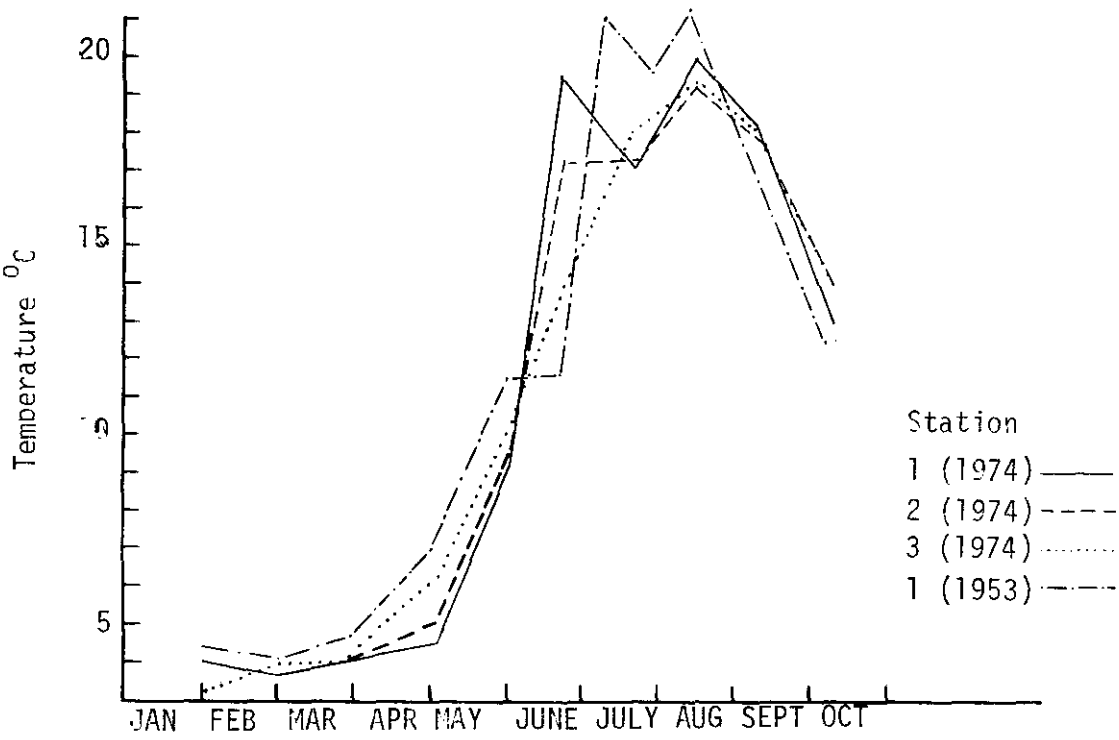

Figure 5. Surface temperature at 3 stations in 1974 and 1 station in 1953, Pend Oreille Lake, Idaho.

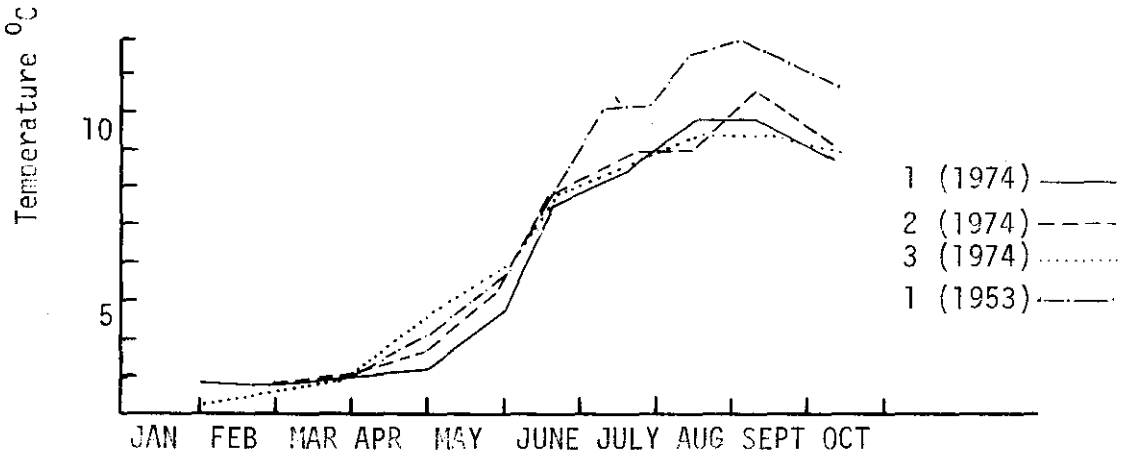

Figure 6. Mean temperature of the upper 46 m at 3 stations in 1974 and 1 station in 1953, Pend Oreille Lake, Idaho.

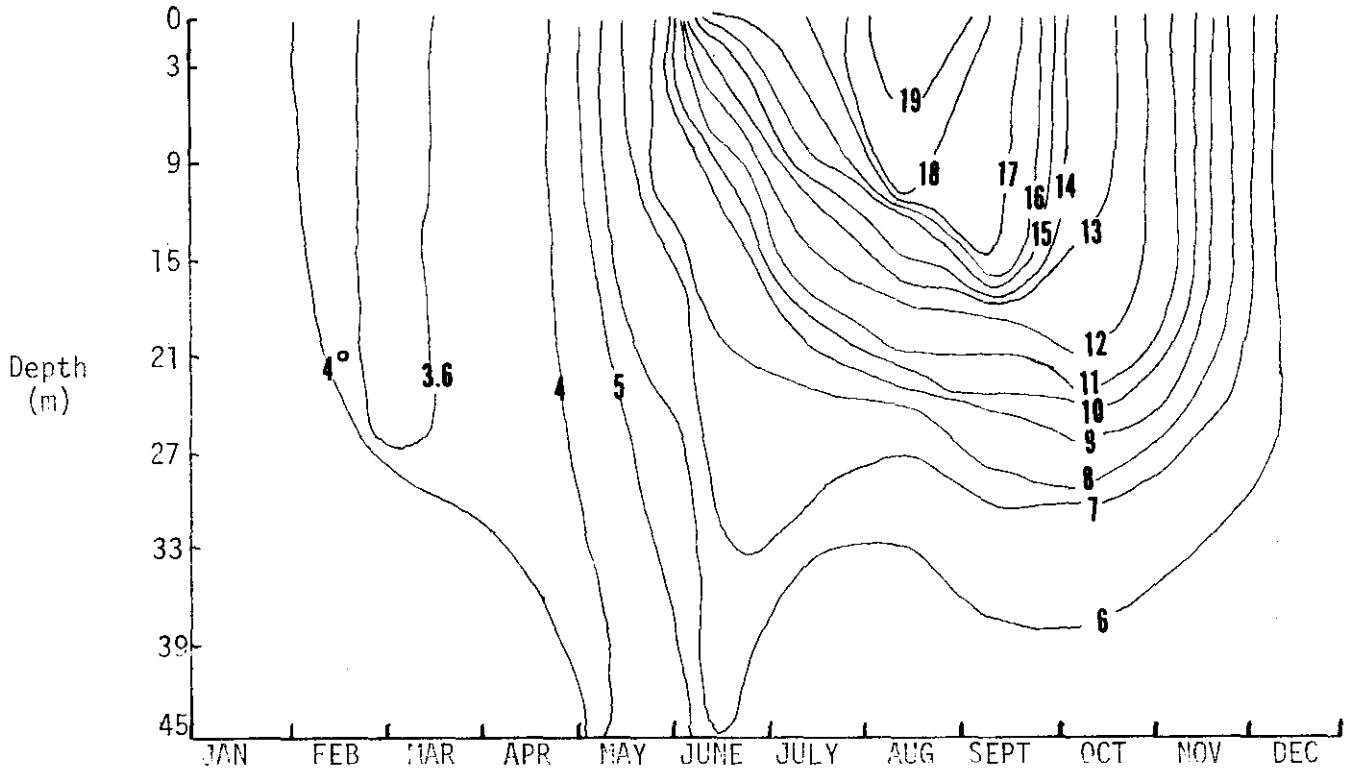

Figure 7. Vertical distribution of isotherms ^{o}C in Pend Oreille Lake, Idaho, 1974.

Wind induced internal seiches vertically displacing isotherms were frequently observed in 1974. A rapid series of temperature profiles along a transect was used to describe differences in isotherm depths. A diurnal series of temperature profiles at a single point on 2-3 July, showed daily fluctuations of nearly 31 meters in individual isotherms (Figure 8). Seiching of this nature may play an important role in vertical mixing of the water column during periods of stratification. Due to the degree of seiching, strict interpretation of thermal patterns is limited to obvious seasonal trends.

pH and alkalinity

Pend Oreille pH values in 1974 varied from 7.6 in the spring to highs of 8.4-8.7 in near surface waters from May to early September (Table 2). Surface pH rose sooner at the two southern most stations, indicating reduced spring algal activity caused by turbid Clark Fork runoff at the northern station. Seasonal trends differed from 1953 (Table 3). The 1974 high surface pH values were earlier and of longer duration than in 1953. Deep water trends were similar for the two years. The surface pH values indicate higher and more prolonged levels of primary production in 1974.

Methyl orange alkalinity in surface waters ranged from 91 mg/l at station 1 on 2 May 1974 to 65 mg/1 at station 2 in July. At 300' a high of 105 mg/1 was recorded on 1 June 1974 at station 3 and a low of 76 mg/l on 10 September at station 2. Methyl orange alkalinity in 1974 was slightly higher than in 1953 (84 mg/1 to 61 mg/1) but in the same range as the 97 mg/1 noted by Kemmerer in 1923. Seasonal trends were similar between 1953 and 1974, with surface values relatively high in the spring and decreasing through the summer with phytoplankton utilization. However, differences between surface and deep values were greater in 1974. Higher utilization of total carbonates due to higher primary productivity may be indicated. It is not yet known whether the differences in ph and alkalinity represent an actual increase in primary productivity of the lake or simply variation within the range of year to year fluctuation.

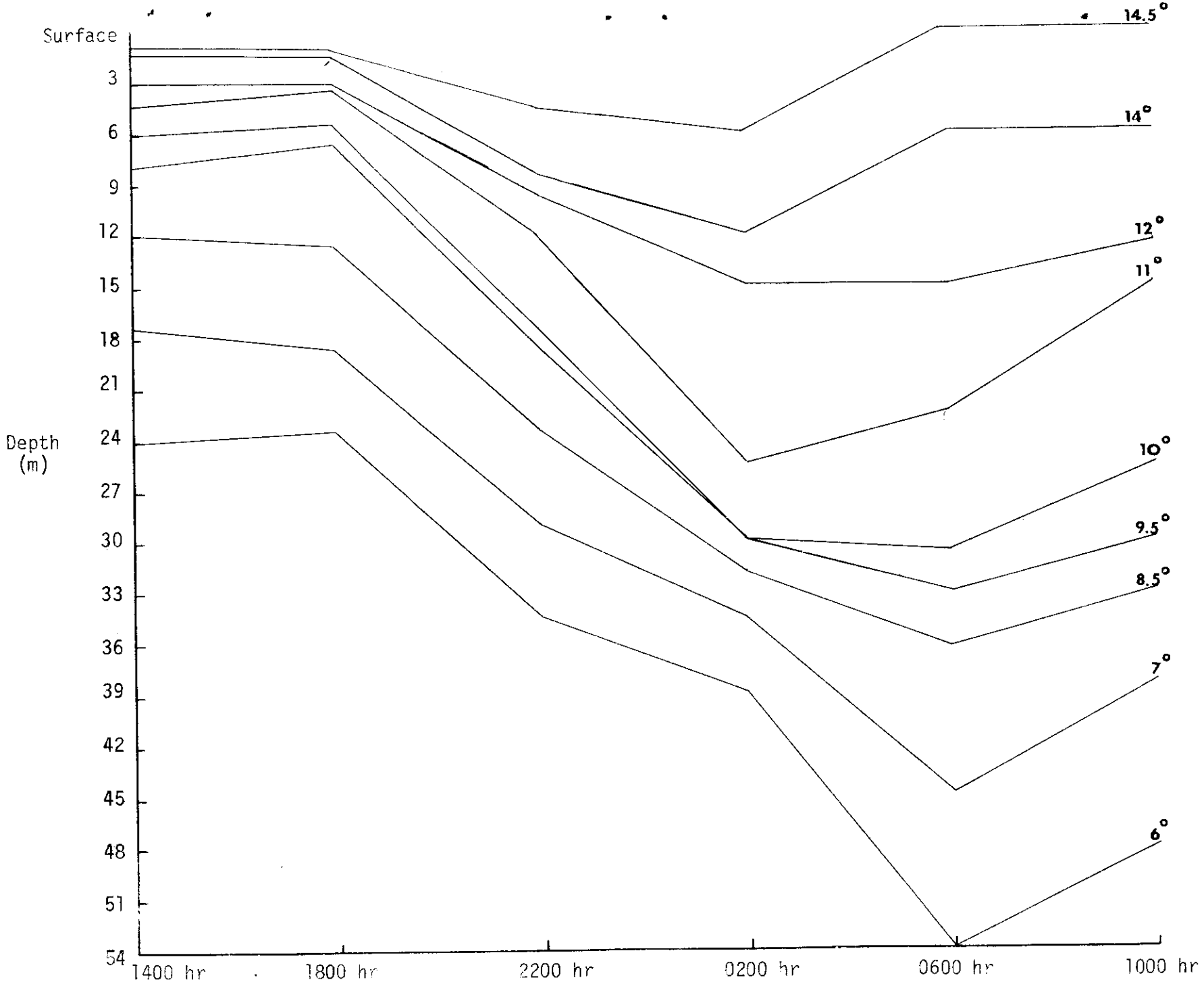

Figure 8. Vertical distribution of isotherms over 24 hours. Echo Bay, Pend Oreille Lake, Idaho. 2-3 July 1974.

Table 2. Selected limnological characteristics, Pend Oreille Lake, 1974.

	Depth (feet)	Meters	Station 1	2	3	1	2	3	1	3	1	2	3	1	2	3
			Feb 1-3			Feb 28-Mar 1			Mar 27-29		May 2-4			May 30-June 1		
Oxygen	0	0	-	-	-	-	-	-	10.9	-	10.8	11.1	11.0	11.8	11.7	11.7
	10	3.0	10.6	9.9	9.6	11.6	9.0	11.6	10.9	9.6	11.2	11.1	11.2	11.9	11.7	11.9
	40	12.2	10.9	9.9	9.4	11.1	8.6	11.8	10.6	11.3	11.0	11.1	11.4	11.9	11.5	11.6
	100	30.4	10.9	-	10.3	11.3	9.2	11.5	10.8	11.1	10.8	10.9	10.9	11.2	11.4	11.3
	150	45.6	10.9	9.11	10.8	12.6	9.9	11.0	10.9	11.0	10.7	10.7	8.9	11.2	11.2	11.1
	300	91.2	-	-	10.7	11.2	10.1	11.0	10.6	10.8	10.6	10.7	10.4	11.1	11.1	10.9
	900	273.6	10.7	7.8		11.6	8.7		11.0		10.1	10.7		10.6	11.6	
Weighted mean for upper 46 m			10.9	9.10	10.0	11.5	9.1	11.3	10.8	10.9	10.9	10.9		11.7	11.4	11.4
pH	0	0	-	-	-	-		-	7.7	-	8.4	-	8.1	8.4	8.4	8.2
	10	3.0	-	-	-	8.0		7.7	7.7	7.8	8.4	8.2	8.1	8.4	8.4	8.3
	40	12.2	-	-	-	8.0	7.9	7.7	7.7	7.7	8.1	8.3	8.0	8.1	8.1	8.1
	100	30.4	-	-	-	7.6		7.5	7.6	7.8	8.1	8.3	8.0	8.1	8.1	7.8
	150	45.6	-	-	-	7.8		7.5	7.8	7.7	8.8	7.8	8.0	8.1	8.1	7.8
	300	91.2	-	-	-	7.8	7.9	7.7	7.6	7.8	8.1	8.0	8.0	8.0	8.0	7.9
	900	273.6	-	-		7.9			7.6		8.1	8.1 (1150')		8.0	8.0 (1000')	
M.O. Alkalinity mg/l	0	0				--		--	87	--	91	--	88	85	88	87
	10	3.0				88		82	84	86	89	76	82	91	83	83
	40	12.2	86	95	84	81	87	87	85	83	90	76	84	90	85	88
	100	30.4				88		82	83	83	84	76	84	95	81	86
	150	45.6	84	84	90	85	85	88	83	82	82	86	84	86	78	90
	300	91.2				88		83	84	83	80	80	84	91	88	105
	900	273.6				91			85		80	76		89	89	
Conductivity umhos k-25	0	0												172	168	155
	10	3.0				182	152	175	177	147	161	170	154	175	170	160
	40	12.2	180	157	175									177	174	162
	100	30.4												184	181	174
	150	45.6	157	152	180									181	181	186
	300	91.2				190	140	182	166		158	167	182	184	182	185
	900	273.6				188			177	166	165	174		186	187	

Table 2. Continued

	Depth (feet)	Meters	Station 1*	2	3*	1*	2	3*	1*	2	3*	1*	2	3*	1*	2	3*
			June 19-21			July 17-19			Aug 13-15			Sept 10-11			Oct 8-9		
Oxygen mg/l	0	0	10.0	9.6	11.6	9.6	9.5	10.5	8.9	9.1	8.5	9.0	8.2	8.7	10.1	8.8	9.4
	10	3.0	9.7	10.2	12.3	10.1	9.2	10.6	8.8	8.6	8.5	8.8	8.3	8.7	9.8	9.1	9.5
	40	12.2	11.9	10.9	11.8	10.9	9.4	10.3	9.1	9.0	9.2	9.1	7.9	8.5	9.9	8.4	9.4
	100	30.4	11.1	10.7	11.3	11.4	10.0	11.5	11.1	10.6	10.8	10.8	9.2	10.9	10.9	9.7	10.5
	150	45.6	11.5	10.6	11.2	11.5	10.4	11.6	11.7	11.0	10.9	11.7	10.0	11.1	12.0	9.7	11.1
	300	91.2	11.6	10.6	10.8	11.6	10.3	11.7	11.7	11.1	11.3	12.2	10.4	11.2	12.2	10.5	11.6
	900	273.6	10.9[I]	--		10.6[I]	9.9		--	11.0		10.8[I]	10.4		--	10.2	
Weighted mean for upper 150'			11.1	10.4	11.4	10.9	9.7	10.7	10.1	9.8	9.8	10.0	8.7	9.8	10.6	9.1	10.0
pH	0	0	8.6	8.3	8.1	8.6	8.5	8.6	8.5	8.3	8.4	8.4	7.9	8.7	8.2	8.1	8.2
	10	3.0	8.6	8.3	8.1	8.6	8.4	8.6	8.5	8.6	8.3	8.4	8.3	8.7	8.2	7.9	8.2
	40	12.2	8.5	7.6	8.2	8.1	7.9	7.9	8.2	7.9	7.8	8.0	8.0	8.5	8.1	7.9	8.2
	100	30.4	8.2	7.9	8.1	8.0	7.9	8.1	7.9	7.8	8.0	8.0	7.7	7.8	7.9	7.8	7.9
	150	45.6	7.9	7.9	8.0	7.8	7.9	8.0	8.0	7.8	8.0	8.1	7.8	7.9	8.0	7.9	7.9
	300	91.2	7.8	7.9	7.7	7.8	7.9	7.7	8.0	7.7	8.0	8.2	7.7	7.9	8.0	7.8	8.0
	900	273.6	7.9[I]	--		8.1[I]	7.9		--	7.8		8.2	8.1		--	7.9	
M.O. Alkalinity mg/l	0	0		66			65			71			66			73	
	10	3.0	71	71	58	70	66	70	62[I]	66	70[I]	68	65	75	72	70	72[I]
	40	12.2		73			78			69			67			73	
	100	30.4		78			77			76			70			77	
	150	45.6		84			80			80			78			77	
	300	91.2	82	84	82	81	81	82	82	78	82[I]	80	76	81	81	80	80[I]
	900	273.6	85[I]	--		78[I]	81		80[I]	83		80[I]	78		82[I]	77	
Conductivity umhos k-25	0	0		158			144			158			155		166[I]	164	
	10	3.0	145	150	--	146[I]	145	151	148[I]	153	157[I]	155[I]	156	--	166[I]	165	165
	40	12.2		154			149			154			160		165[I]	165	
	100	30.4		176			171			176			176			167	
	150	45.6		178			175			183			176		180[I]	179	
	300	91.2	188	188	186		178			185	183[I]		179	--	178[I]	182	184
	900	273.6	185[I]	--		184[I]	184	189	182[I]	187		185[I]	184		186[I]	186	

Table 3. Seasonal trends in mean pH values in Pend Oreille Lake, 1953 and 1974.

Depth (feet)		Feb 1-3	Mar 1-3	Mar 27 -Apr 4	May 1-2	June 1-3	June 19-24	July 19-24	Aug 12-15	Sept 3-10	Oct 3-8
0	1974	-	-	7.7	8.2	8.3	8.3	8.5	8.4	8.3	8.2
0	1953	7.9	7.8	7.7	7.8	8.3	7.9	8.3	8.3	8.1	8.0
300'	1974	-	7.8	7.7	8.0	7.9	7.8	7.8	7.9	7.9	7.9
400'	1953	7.8	7.7	7.8	7.6	7.8	7.7	7.7	7.7	7.6	7.6

Table 4. Seasonal trends in mean Methyl Orange alkalinity. Pend Oreille Lake, 1953 and 1974.

Depth (feet)		Feb 1-3	Mar 1-3	Mar 27 -Apr 4	May 1-2	June 1-3	June 19-24	July 19-24	Aug 12-15	Sept 3-10	Oct 3-8	Mean
0	1974	-	-	87	89	87	66	65	71	66	73	76
0	1953	75	75	70	73	65	65	65	66	70	73	70
300'	1974	-	86	84	82	95	82	81	81	79	80	83
400'	1953	77	76	71	74	73	72	72	72	75	74	74

Table 5. Comparison of seasonal trends in mean dissolved oxygen (mg/l). Pend Oreille Lake, 1953 and 1974.

Depth (feet)	Feb 1-3	Mar 1-3	Mar 27- Apr 4	May 1-2	June 1-3	June 19-24	July 19-24	Aug 12-15	Sept 3-10	Oct 3-8
0 1974	-	-	10.9	11.0	11.7	10.4	9.8	8.8	8.6	9.4
0 1953	11.3	11.7	11.6	11.8	11.5	11.3	8.5	-	8.5	9.3
150' 1974	10.3	11.1	10.9	10.1	11.2	11.1	11.2	10.9	10.9	10.9
200' 1953	10.7	10.9	11.1	11.6	11.6	11.6	11.0	-	10.9	10.7

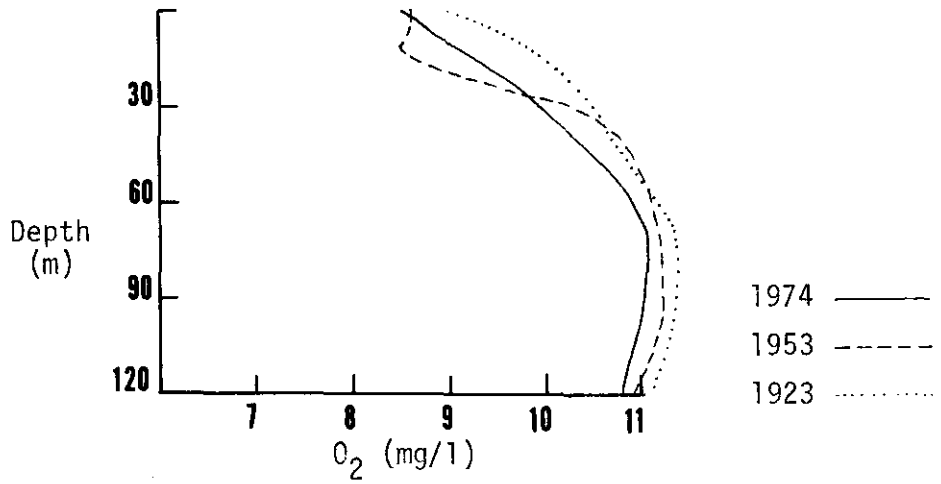

Figure 9. Oxygen content at maximum stratification*, Pend Oreille Lake, 1923, 1953, and 1974.

*(1923 data is available only for July)

Table 6. Nitrates and orthophosphates at three sites, Pend Oreille Lake, 1974.

Date	Station 1 South NO_3-N (mg/l)	Station 2 Mid NO_3-N (mg/l)	Station 3 North NO_3-N (mg/l)	Station 1 South $O\text{-}PO_4$-P (mg/l)	Station 2 Mid $O\text{-}PO_4$-P (mg/l)	Station 3 North $O\text{-}PO_4$-P (mg/l)
February 1-3						
40'	.080	.100	.094	<.005	.006	.006
200'	.073	.095	.098	.006	<.005	<.005
February 28-March 1						
10'	.070	.077	.093	<.005	<.005	<.005
350'	.092	-	.092	<.005		<.005
900'	.100	.090		<.005	.007	
March 27-29						
10'	.075	-	.065	<.005	-	<.005
350'	.076	-	.065	<.005	-	<.005
900'	.082	-		<.005	-	
May 2-4						
10'	.052	.037	.042	.006	<.005	<.005
350'	.070	.065	.082	.006	.006	.007
900'	.085	.080		.009	.007	
May 30-June 1						
10'	.018	.015	.018	<.005	<.005	<.005
350'	.069	.074	.080	.006	.006	.008
900'	.080	.083		.008	.009	
June 19-21						
10'	.000	.020	-	<.005	<.005	-
300'	.050	.089	-	<.005	<.005	-
900'	.095	-		.007	.008	
July 17-19						
10'	.000	.015	.000	<.005	<.005	-
300'	-	.103	.010	-	.008	
900'	.087	.074		.007	.007	-
August 13-15						
10'	.04	.020	.030	-	<.005	-
300'	.06	.079	.11	-	.006	-
900'	.084	.095		.007	.008	-
September 10-11						
10'	-	.018	-	-	<.005	-
300'	-	.101	-	-	<.005	-
900'	.099	.098	-	.006	.006	-
October 8-9						
10'	.028	.013	.013	.007	.005	<.005
300'	.100	.097	.110	.005	<.005	.006
900'	-	.102		-	.008	

Oxygen

Oxygen content in Pend Oreille Lake was high throughout 1974 (Table 2). Maximum surface oxygen content was 11.8 mg/1 in the southern end of the lake in late May. Minimum surface oxygen content was 8.2 mg/1 at mid-lake in September. Maximum oxygen content recorded was 12.6 mg/1 at 46 m (150') in the south end in February. Mean oxygen content for the upper 46 m was lowest for all 3 stations during the period of maximum lake stratification. Comparison of 1974 and 1953 oxygen show similar conditions in both years (Table 5). Stratification of oxygen was evident in 1923, 1953 and 1974 (Figure 9). The high oxygen content in deep waters and the similarity of oxygen stratification each year indicates little change in the oligotrophic nature of Pend Oreille.

Conductivity

Conductivity ranged from 140 to 190 umhos/cm^2 in 1974 (Table 2). Dissolved materials were reduced in epilimnial waters by phytoplankton activity as summer progressed. Maximum stratification was noted in September. Mixing had begun in epilimnial waters by October and conductivity was relatively uniform to 30 meters (100'). We found conductivity in surface waters to be much lower in the north end of the lake from March-May (complete data was not obtained in June). The lower levels reflect dilution by the Clark Fork River (conductivity 118 umhos in June) at spring flood. Conductivity profiles indicate that most of the Clark Fork water remained in surface layers as it passed through the lake.

Nutrients

Nitrate nitrogen varied from 0 to .100 mg/1 throughout 1974 (Table 6). Stratification of NO_3•N was obvious during late summer with minimum concentrations (.0-.020 mg/l) in upper waters during June and July at the time of minimum transparency. High phytoplankton utilization and possible limitation is indicated by these minimal NO_3-N values. No consistent differences were observed between stations.

We found very low levels of ortho phosphate phosphorous in 1974, ranging from <. 005 mg/1 to .009 mg/1. In most samples 0-PO_4'P was below detection limits (.005 mg/1). The highest concentrations occurred in deeper waters as summer and stratification progressed. These low levels of 0-PO_4'P in Pend Oreille also indicate the possibility of phosphate limitation.

Clark Fork River

The Clark Fork River, the major inlet, is similar to the lake in physical and chemical properties (Table 7) except during flood. River flows (Figure 10) peaked in late spring at 12 times the September low flows. During runoff high silt loads result in greatly reduced transparencies. In June, alkalinity and conductivity were relatively low and 0-PO_4'P was high. A diagram based on our observations has been constructed to show probable Clark Fork influence and water mass movement in the lake (Figure 11). Most inflowing water passes directly into the north arm; the result is highly reduced transparency, dilution, and faster flushing time in the northern arm. Mean flushing time ranges from approximately 100 days in the northern arm to approximately 1200 days in the isolated southern end. The Clark Fork River is, therefore, undoubtedly an important factor in the reduced north-end productivity.

Increased turbidity is also responsible for earlier warming of the north end of the lake. The warming might possibly result in earlier resumption of kokanee feeding and explain what had previously been interpreted as a northward migration of fish. Fish and Game gill netting operations indicate higher numbers of young fish in the northern lake (Bowler, 1974 personal comm.). Higher turbidity may play an important role in the increased survival of young fish from predation.

Zooplankton

Macrozooplankton analysis is complete through September, 1974. Although species identifications are not yet confirmed, a tentative species list is as follows: Cyclops bicuspidatus, Diaptomus ashlandi,

Table 7. Selected limnological characteristics; mouth of Clark Fork River, 1974.

	20 June	14 August	9 October
Secchi	.18 m (.9')	3.8 m (12.5')	4.2 m (14')
O_2 (mg/l)	11.85	-	-
Temperature (^{o} C)	-	19^{o} C	13.5^{o} C
pH	7.8	-	-
M. O. Alkalinity (mg/l)	56	76	76
Conductivity (umhos)	118	170	165
NO_3·N (mg/l)	.036	.017	.013
D-PO_4·P (mg/l)	.011	<.005	.006
Flow (cfs)	129,600	15,780	15,580

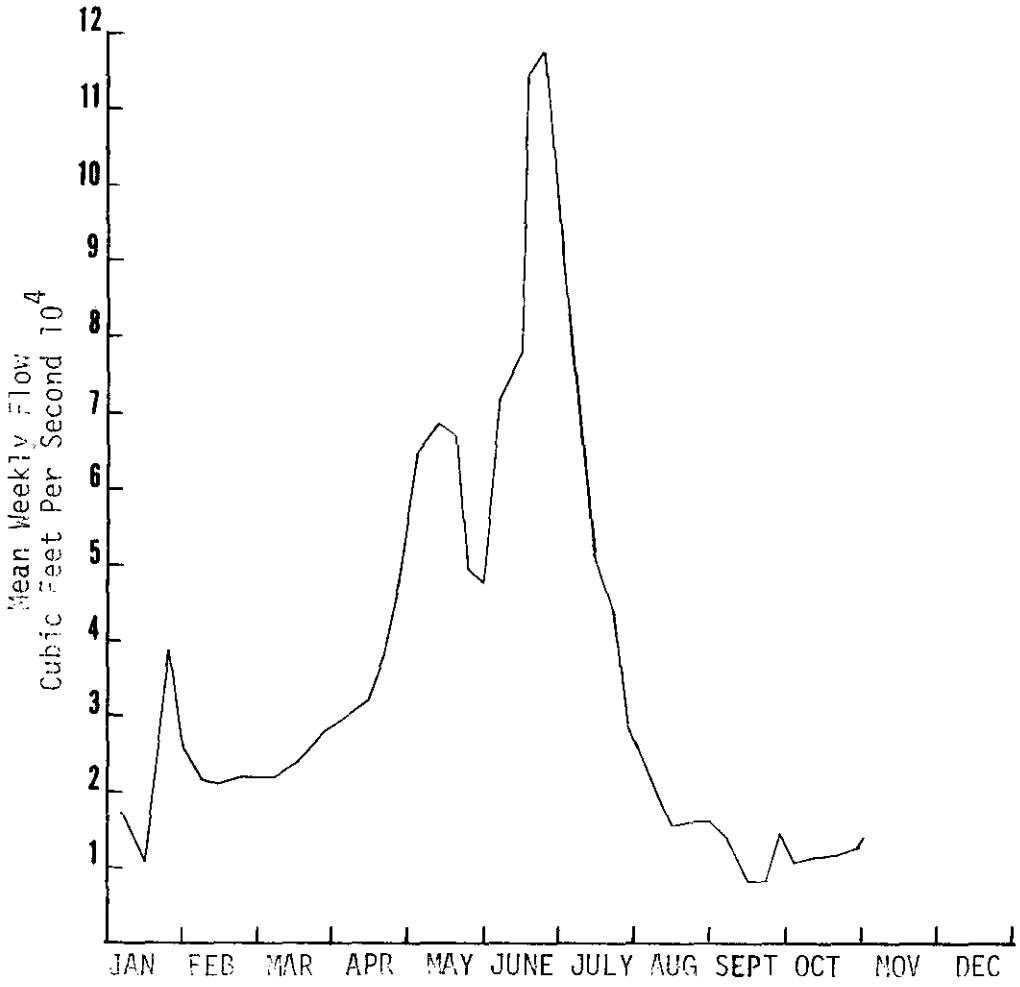

Figure 10. Mean weekly flow of the Clark Fork River below Cabinet Gorge Dam, 1974.

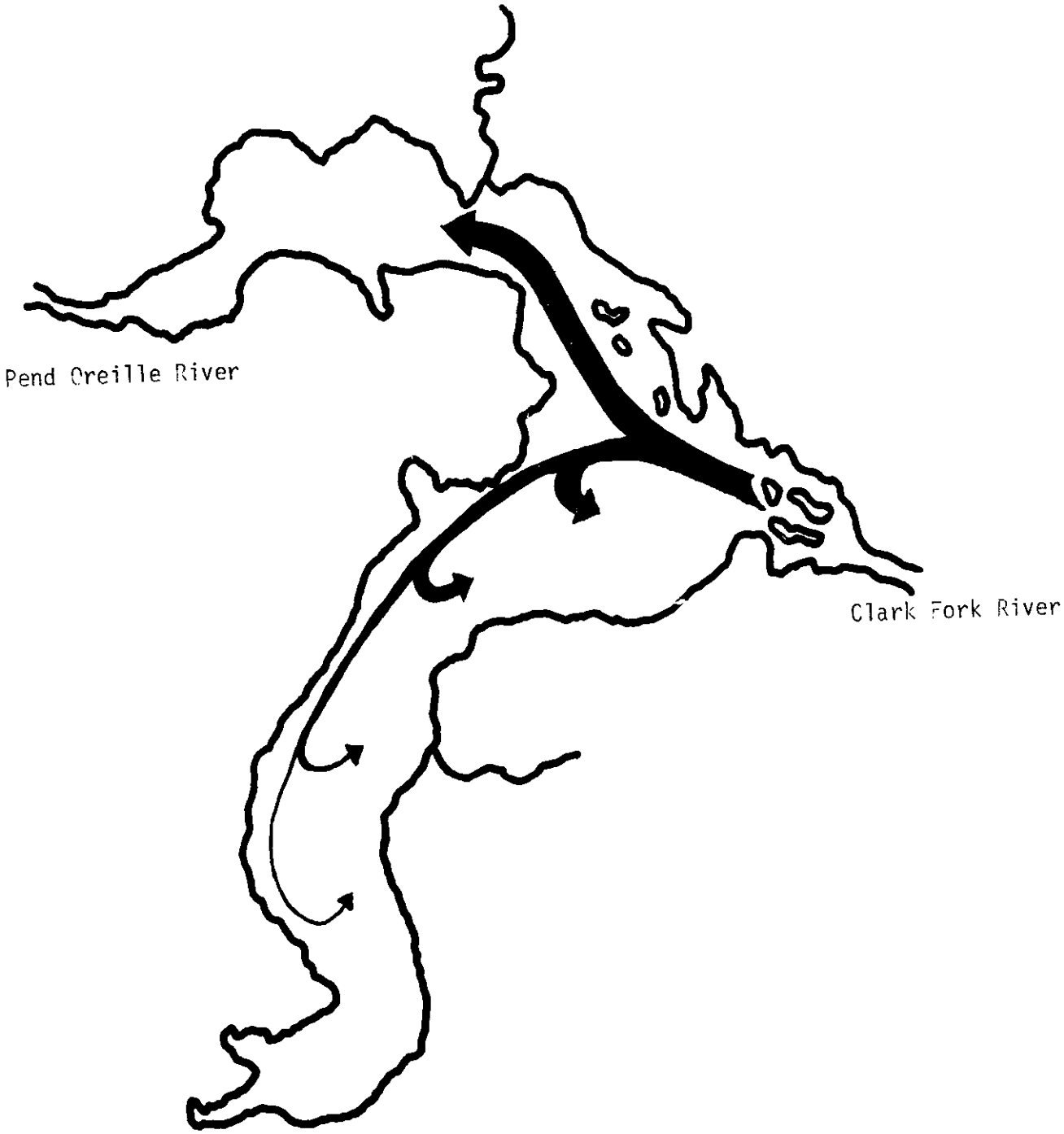

Figure 11. Probable Clark Fork influence and water exchange in Pend Oreille Lake.

Epischura nevadensis, Daphnia thorata, Bosmina lonqirostris, Leptodora kindtii, and Mysis relicta. Because of the nature of the data reported in 1954, comparison of zooplankton standing crops has been limited to averages for the entire lake. Estimates from 1974 used in comparisons are based only on samples taken in the same locations as the earlier study stations. Mysis is not included in total zooplankton because of its very large size, and sporadic occurrence in samples.

The trends in zooplankton standing crop (Figures 12 and 13) were similar in all five sections. However, large differences were observed in both total numbers and biomass. As the season progressed, total zooplankton standing crop was generally higher in the southern section than in the northern section. The mean summer standing crop (30 May-11 September) was 46 mg zooplankton dry weight biomass /m^3 in the south-ern section, 33 mg/m^3 in the mid-section, and 26 mg/m^3 in the 3 northern sections combined (Figure 14) . The trend in zooplankton standing crop reflects the influence of the Clark Fork River in reducing production of the northern lake. Mean total zooplankton in 1974 was very similar to 1953 levels (Figure 15). Summer means (20 May-September) were 11.6 total individuals/liter in 1953 and 11.2/liter in 1974.

Biomass followed total numbers through the 1974 season (Figure 16). A correlation coefficient of r=.76 was obtained between the two estimates (Figure 17). As the season progressed the large forms in the zooplankton became more important. This assumption is born out by a positive correlation (r=.69) between percent Daphnia numbers in the zooplankton and mean dry weight per individual; and also by a negative correlation (r=-.73) between percent Cyclops numbers and mean dry weight per individual. Daphnia is the most numerous "large" zooplankter in Pend Oreille and approximately 10 times the size of Cyclops, the most abundant species throughout the year.

Cyclops

Cyclops was present in all samples and numerically dominant through-out the year (Table 8). A peak density of 21.7 Cyclops/liter was found in one sample from section 1 on 18 July. Mean standing crops differed

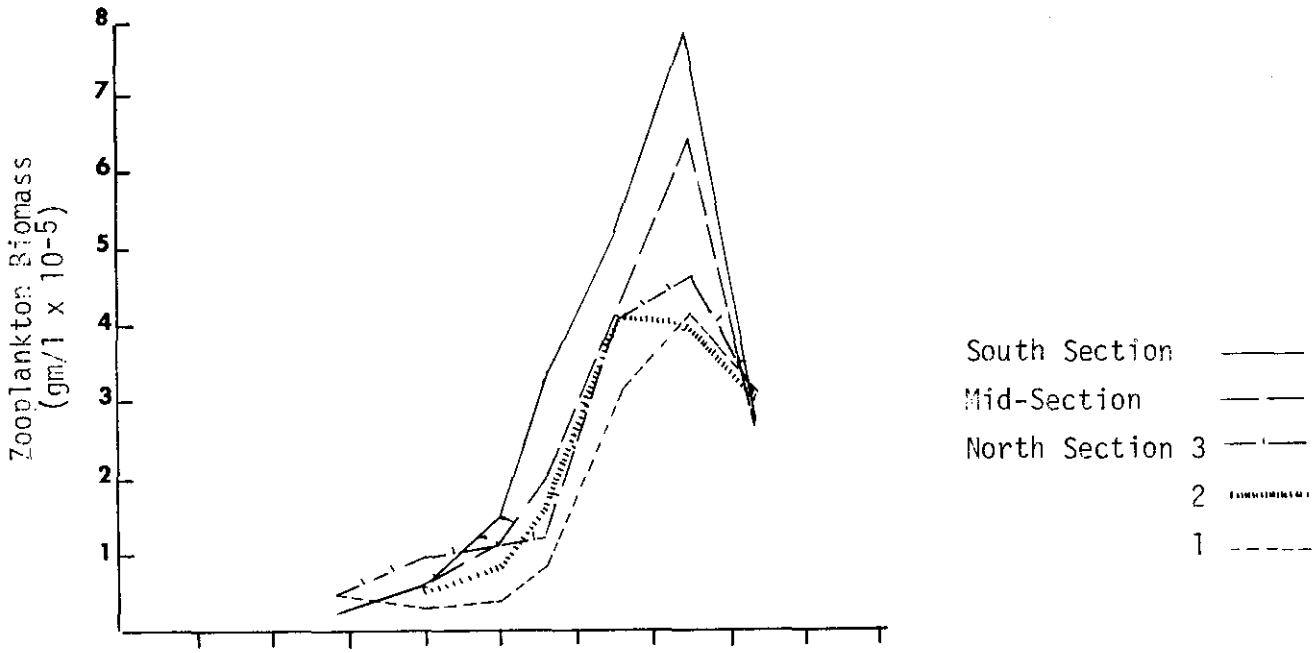

Figure 12. Mean zooplankton dry weight biomass in 5 sections of Pend Oreille Lake, Idaho, 1974.

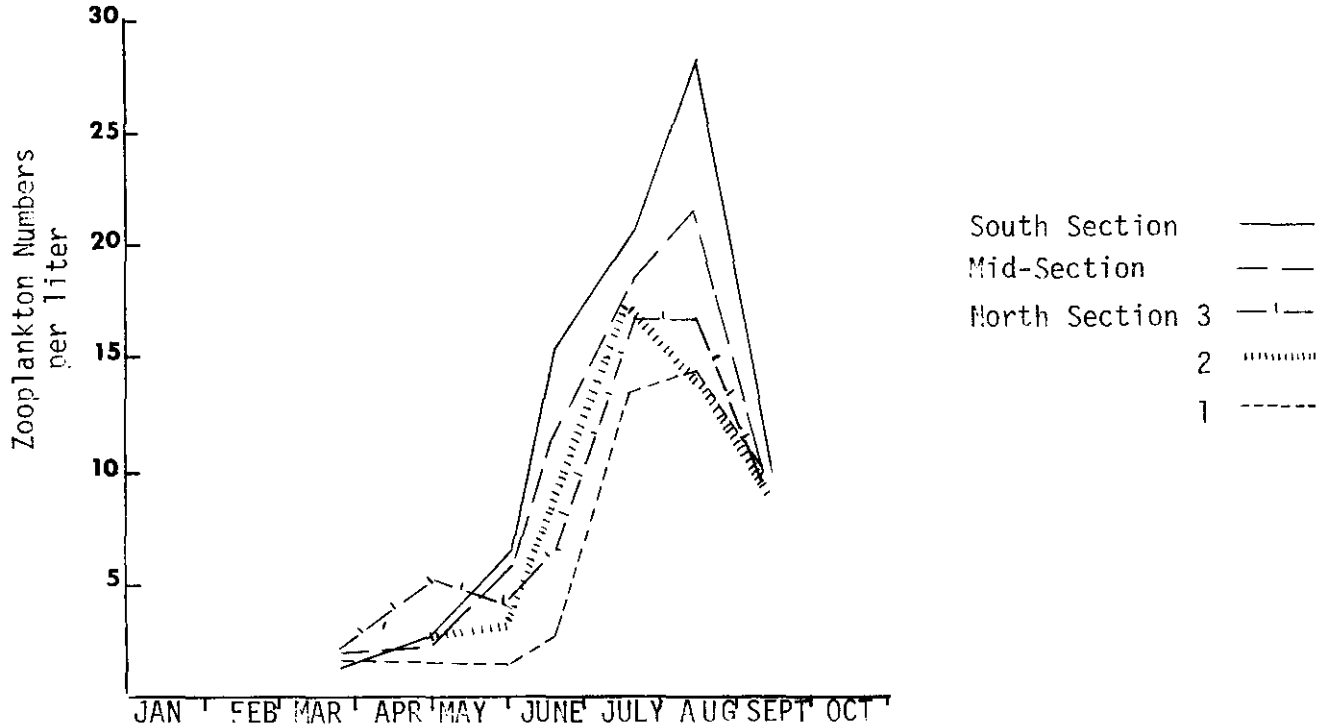

Figure 13. Mean total zooplankton numbers in 5 sections of Pend Oreille Lake, Idaho, 1974.

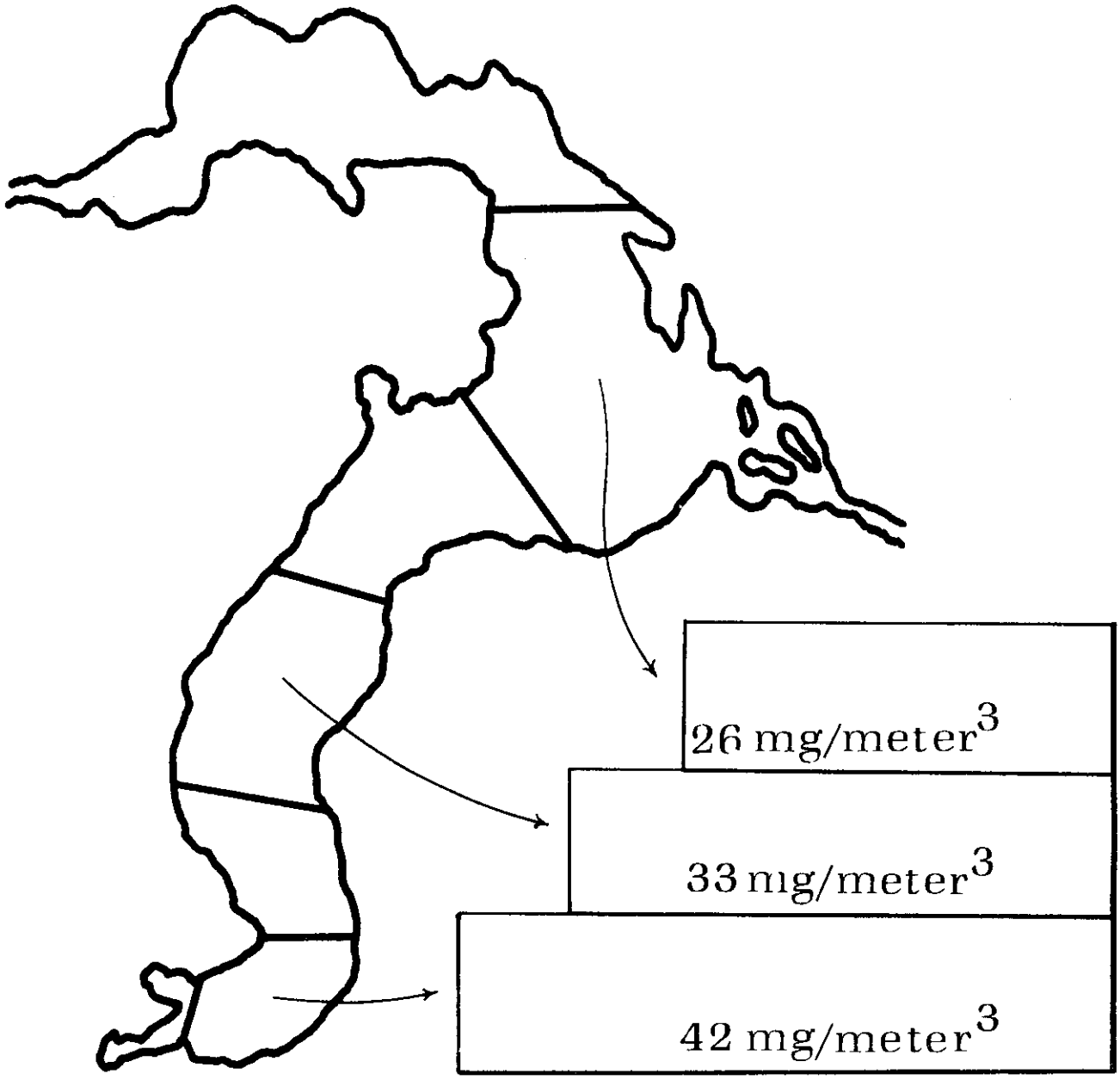

Figure 14. Mean summer zooplankton dry weight biomass in 3 sections of Pend Oreille Lake, Idaho, 1974.

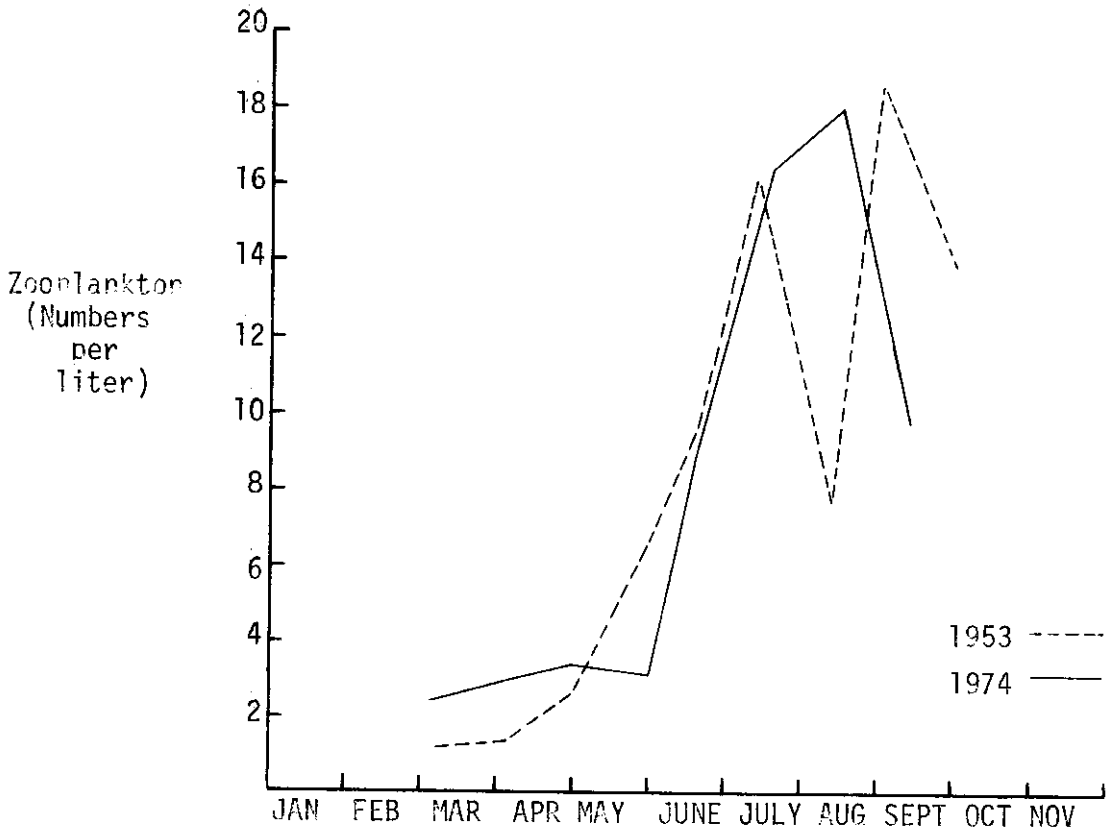

Figure 15. Mean total zooplankton numbers for Pend Oreille Lake, Idaho, 1953 and 1974.

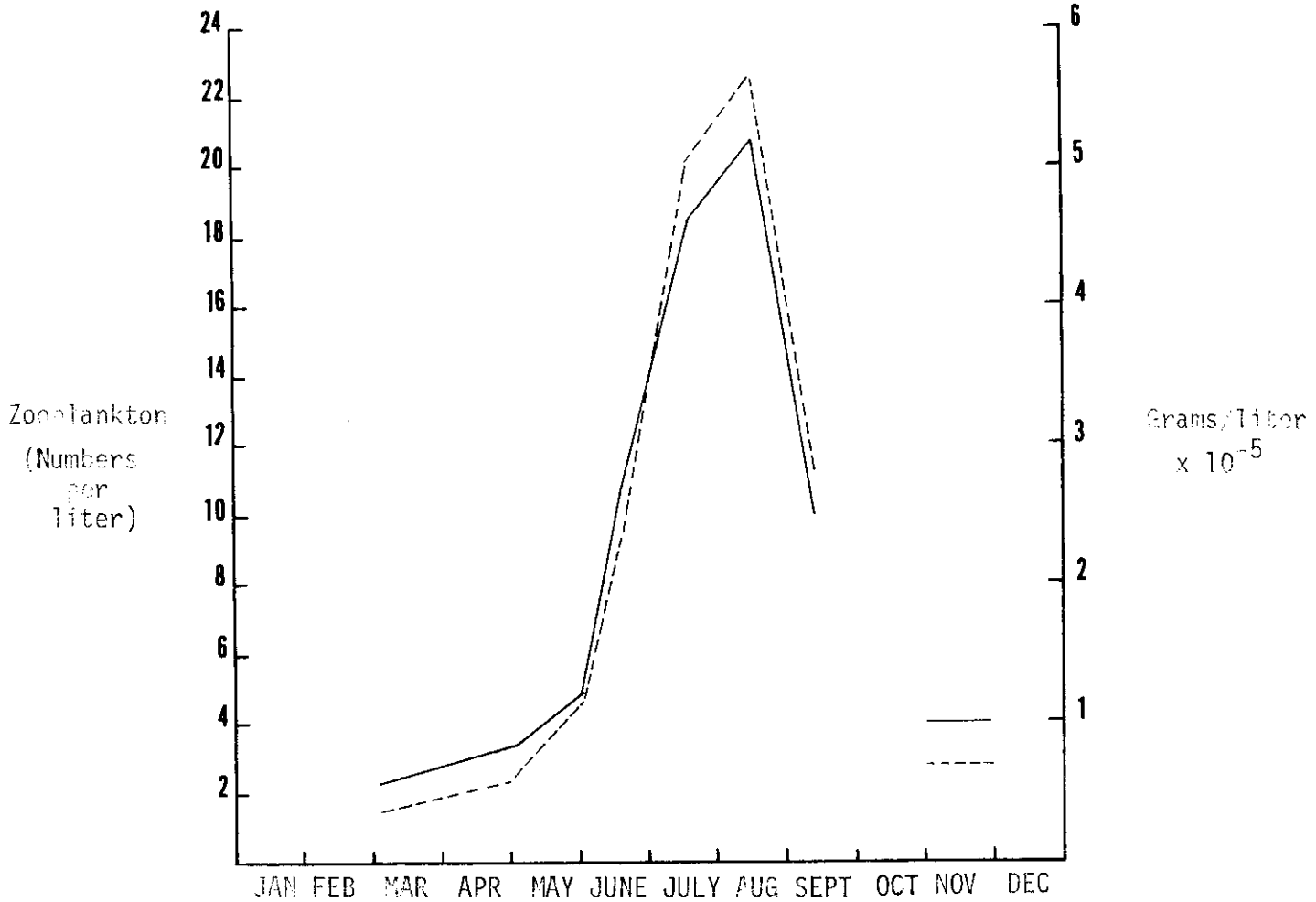

Figure 16. Mean total zooplankton numbers and biomass in Pend Oreille Lake, Idaho, 1974.

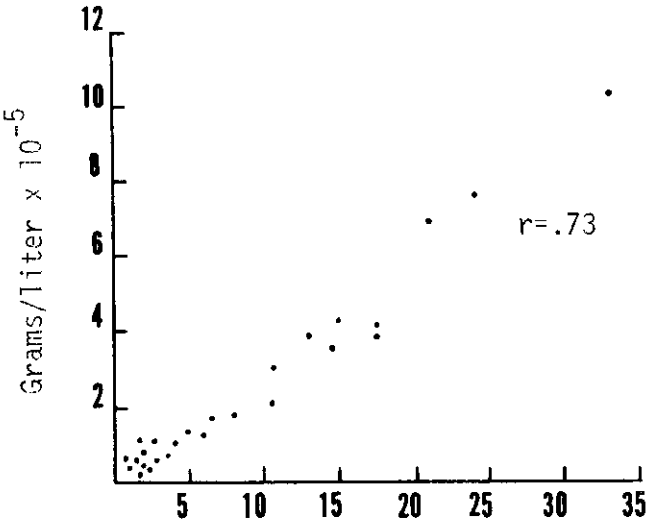

Figure 17. Total zooplankton numbers vs. dry weight biomass, Pend Oreille Lake, Idaho, 1974.

greatly between sections (Figure 18). Mean density peaked at 15.25 Cyclops/liter in section 1; 12.78/liter in section 2; 6.77/liter in section 3(1); 7.93/liter in section 3(2) and 8.75/liter in section 3(3). Cyclops populations in the northern 3 sections started at higher densities in March than other sections, but fell off sharply in late May. The initially higher populations in the north may have been due to waters warming earlier.

The sharp late spring decline in Cyclops corresponds with a subpeak in Clark Fork runoff. It is not clear why the reduction in numbers of Cyclops was not evident in other species. Increased flushing time may have reduced Cyclops numbers alone if generation times were significantly shorter or birth rates higher in the other plankters.

Mean Cyclops standing crops for the entire lake in 1974 standing crops were slightly delayed relative to 1953, probably as a result of the cooler water year.

Diaptomus

We found Diaptomus in plankton samples throughout the year (Figure 20). Numerically Diaptomus was usually the second most important component of the zooplankton comprising up to 45% of the total (Table 8). An early peak of copepodids (sub-adults) was noted in late May and a second in August (Figure 21). Adults peaked with a maximum of 8.90 individuals/liter in one sample from section 1 in August. A second peak may have existed in late fall, (indicated by copepodid peaks). Again standing crops reached higher levels in the southern sections.

During early summer, Diaptomus standing crops were higher in 1974 than in 1953. However, 1974 populations appear to have peaked at only half the 1953 levels (Figure 22). Analysis is not yet finished on October and December, 1974 samples when Diaptomus populations should have been relatively high.

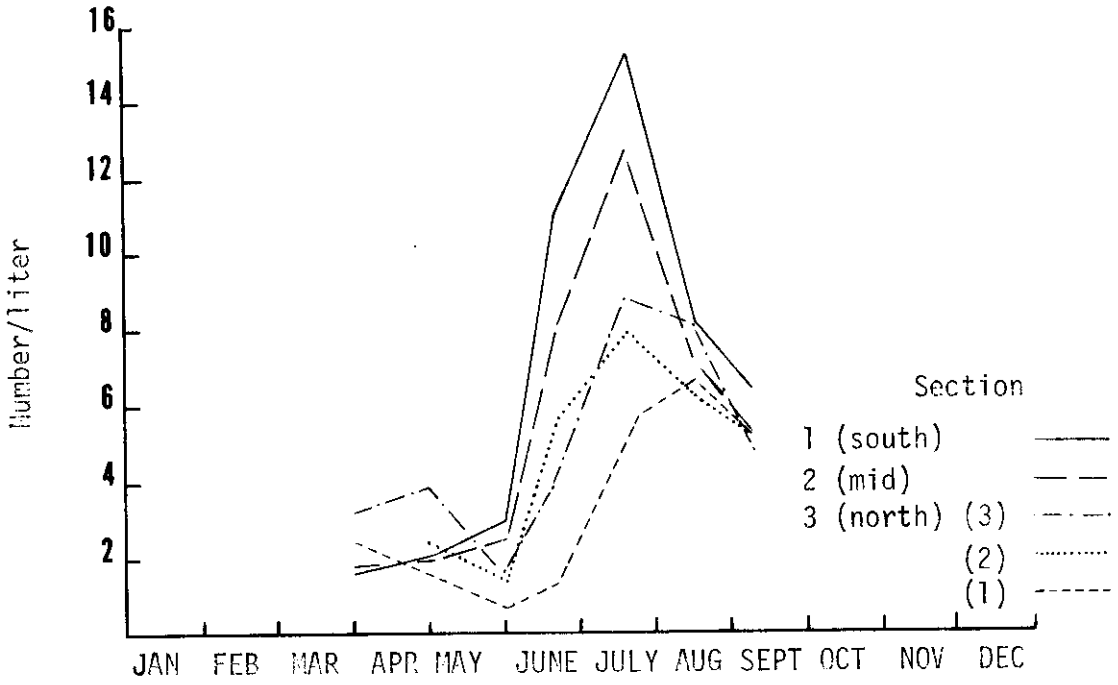

Figure 18. Mean Cyclops numbers in Pend Oreille Lake, Idaho, 1974.

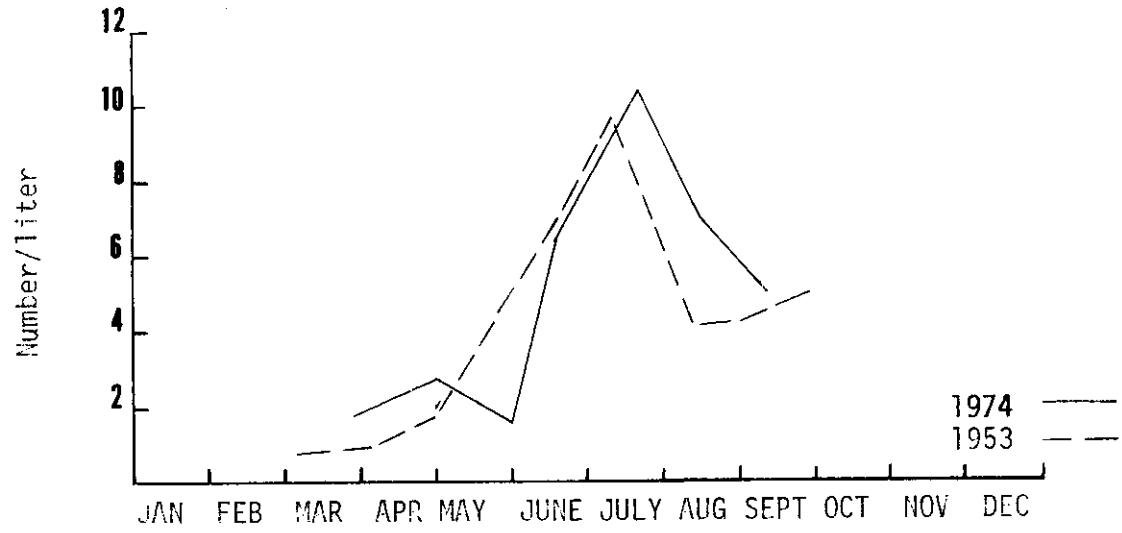

Figure 19. Mean Cyclops numbers in Pend Oreille Lake, Idaho, 1953-1974.

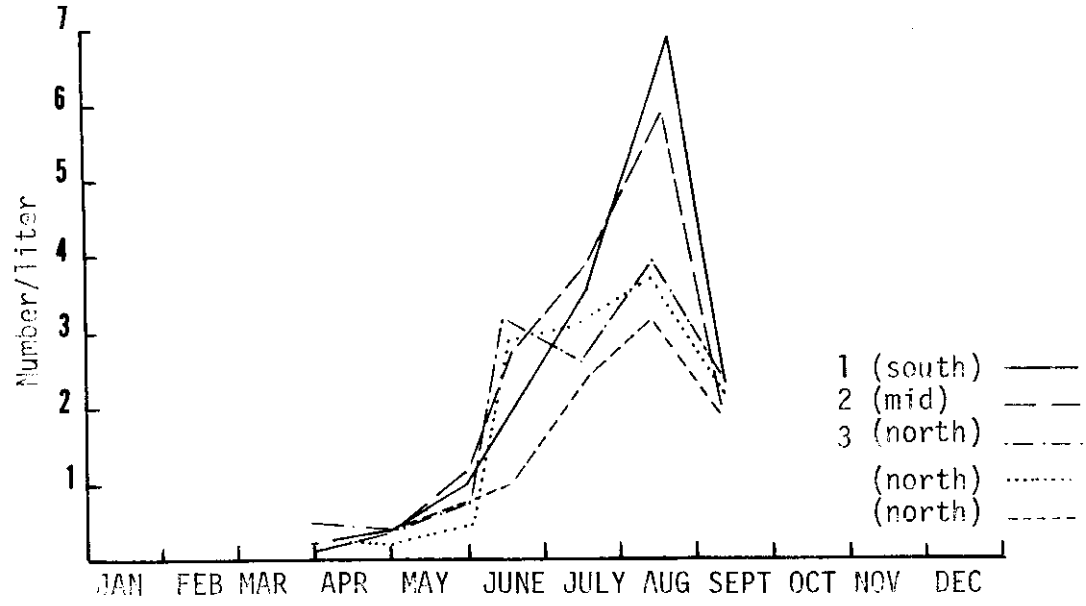

Figure 20. Mean Diaptomus adult numbers in Pend Oreille Lake, Idaho, 1974.

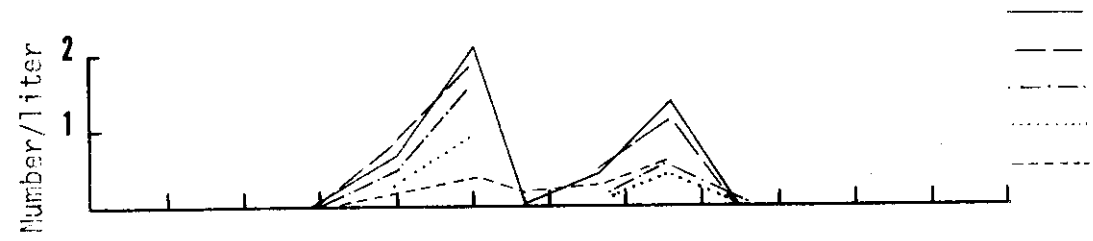

Figure 21. Mean Diaptomus copepodid numbers in Pend Oreille Lake, Idaho, 1974.

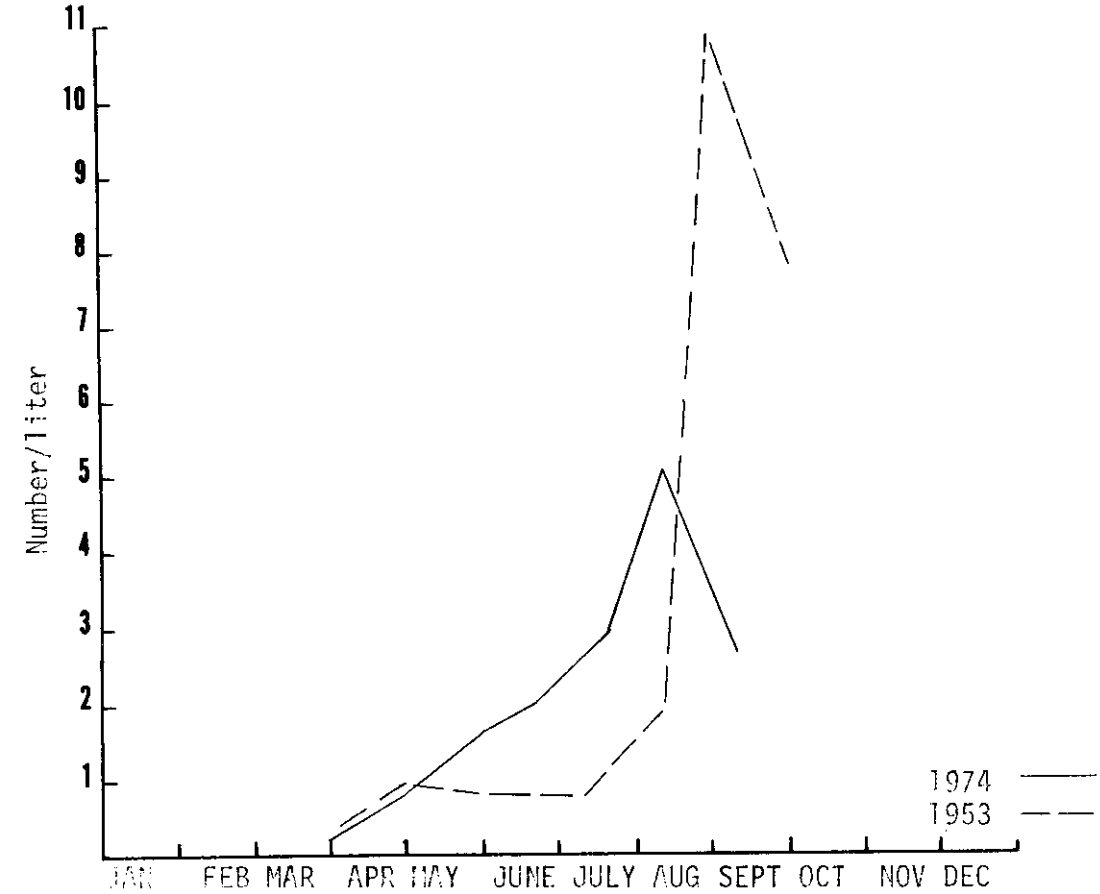

Figure 22. Mean Diaptomus numbers in Pend Oreille Lake, Idaho, 1953-1974.

Daphnia

We found Daphnia sporadically in samples from March to July when populations began to increase (Figure 23). Standing crops were usually higher in the southern two sections. Mean section density peaked at 7.57 Daphnia/liter in section 1 and 5.45/liter in section 2. The Daphnia population in the northern 3 sections did not decline as rapidly as in the south. Section 3(1) (the northernmost) apparently did not peak until September at 3.04 Daphnia/liter. The other two sections [3(2) & 3(3)] reached 2.0 Daphnia/liter.

Numerically Daphnia was an important component of the zooplankton, comprising up to 33% of the total. Due to its relatively large size and high degree of utilization by kokanee. Daphnia may be the most important component of the kokanee food supply.

The density and relative numerical importance of Daphnia was greater in 1974 than in 1953 (Figure 25). Daphnia peaked at a mean lake density of 3.72 individuals/liter in 1974 composing 19% of the total zooplankton present (Table 8). Daphnia peaked at 1.95 individuals/liter in 1953 comprising 10% of the standing crop present. Daphnia comprised 5% of the summer mean standing crop numbers in 1953 but 10% in 1974 (Figure 25).

Bosmina

We found Bosmina at low densities (.002-.009/liter) from March to June in all sections (Figure 26). Populations began to increase to a July peak in sections 2, 3(1), 3(2), and 3(3); and in August in section 1. Unlike the other zooplankton, Bosmina standing crops were highest in the northern 3 sections. Section 1 mean density peaked at 4.00 Bosmina/liter, section 2 at 2.05/liter, section 3(1) at 4.16/liter, section 3(2) at 5.95/liter and section 3(3) at 5.19/liter. Bosmina was important numerically and made up to 38% of the tool zooplankton in section 3(3).

Bosmina standing crops were lower in 1974 than 1953 (Figure 27). Bosmina was also of less importance in the total zooplankton in 1974. In 1953, mean Bosmina densities for the lake peaked at 5.6 individuals/liter and 3.1 individuals/liter in 1974. Bosmina comprised 18% of the summer mean numbers in 1953 but 11% in 1974 (Figure 25).

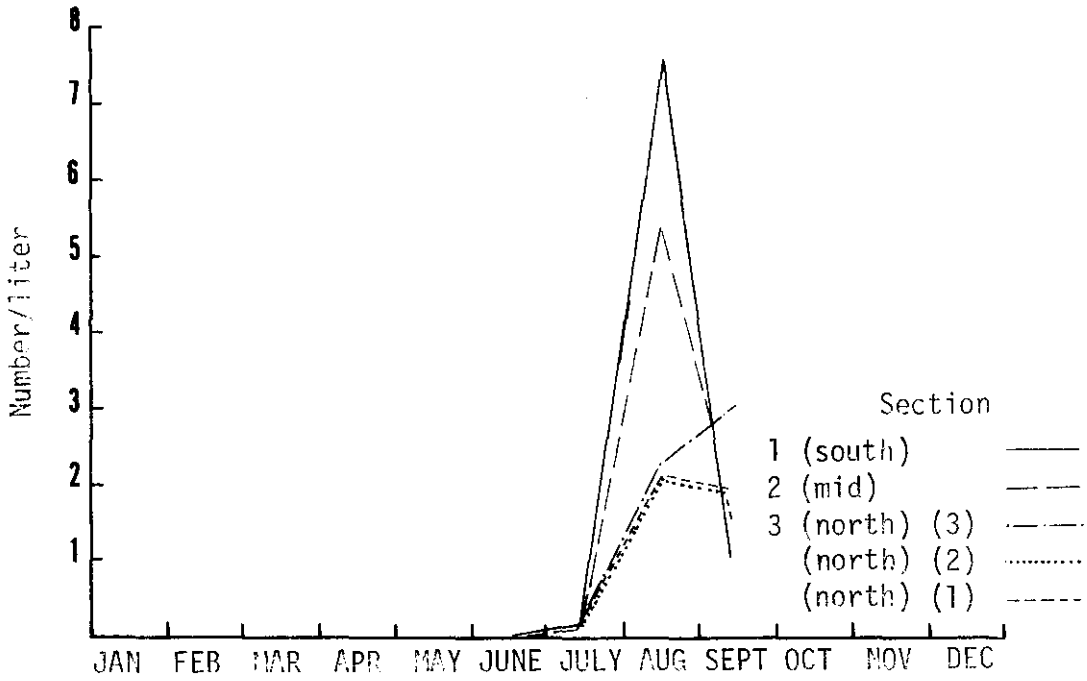

Figure 23. Mean Daphnia numbers in Pend Oreille Lake, Idaho, 1974.

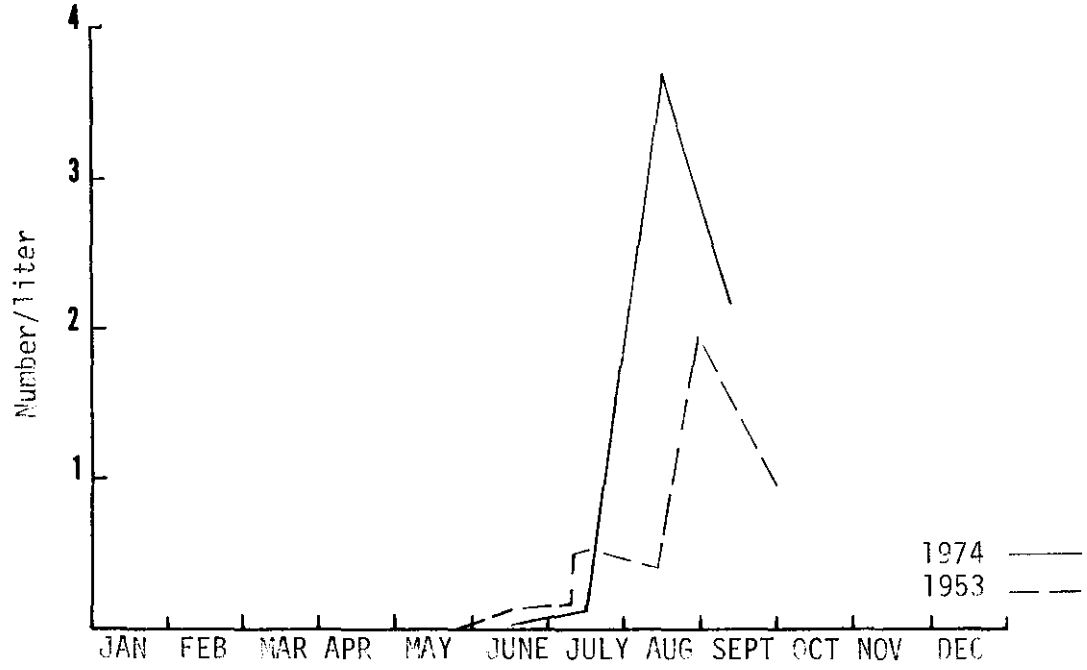

Figure 24. Mean Daphnia numbers in Pend Oreille Lake, Idaho, 1953-1974.

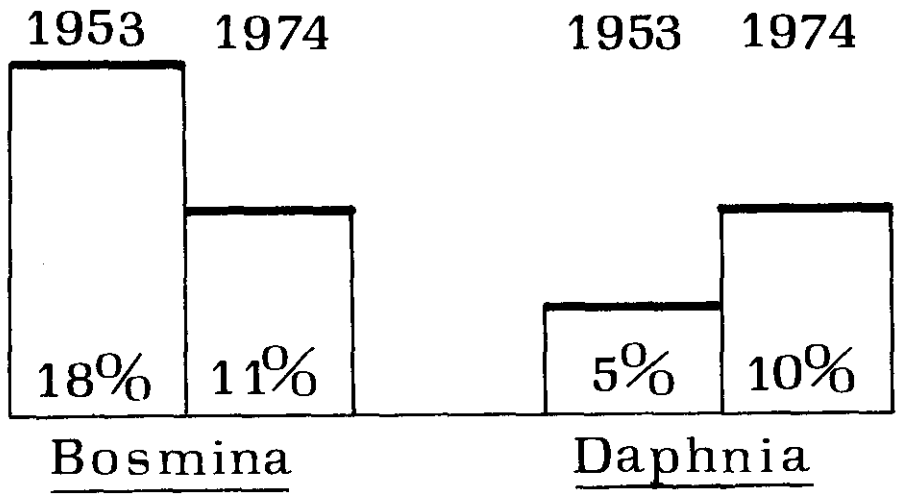

Figure 25. Percent of zooplankton mean summer standing crop for Daphnia and Bosmina, Pend Oreille Lake, Idaho, 1953-1974.

Table 8. Seasonal trends in mean zooplankton standing crop (no./l) and percent composition in Pend Oreille Lake, 1974.

	Number of samples	Cyclops #/liter	% Total	Diaptomus	% Total	Diaptomus Copepodids	% Total	Epischura	% Total	Bosmina	% Total
March 27-29											
Section 1 (south)	(10)	1.6	89	.14	8	.04	2	0	0	.004	.2
Section 2 (mid)	(3)	1.77	90	.14	7	.04	2			.002	.1
Section 3 (1) (north)	(5)	2.45	87	.29	10	.05	2	0	0	.009	.3
(3)	(2)	3.22	84	.56	15	.03	1	0	0	0	
May 2-4											
Section 1	(9)	2.15	64	.42	13	.69	20	0	0	.04	1
Section 2	(6)	2.00	61	.34	10	.83	25	0	0	.10	3
Section 3 (1)	(3)	1.40	72	.21	11	.32	16	0	0	.02	1
(2)	(3)	2.46	82	.20	7	.27	9	0	0	.05	2
(3)	(4)	3.86	76	.48	10	.67	13	0	0	.03	1
May 30-June 1											
Section 1	(9)	3.02	47	.99	16	2.29	36	0	0	.06	1
Section 2	(7)	2.57	45	1.32	23	1.84	32	0		.04	1
Section 3 (1)	(3)	.85	47	.51	29	.40	22	.003		.04	2
(2)	(4)	1.56	50	.57	18	.87	28	.009		.08	3
(3)	(5)	1.74	42	.92	22	1.39	33	0	0	.09	2
June 19-20											
Section 1	(9)	10.95	73	1.93	13	.28	2	.25	2	1.44	10
Section 2	(7)	8.10	71	2.63	23	--		.07	1	.47	4
Section 3 (1)	(3)	1.67	50	1.04	31	--		.04	1	.58	17
(2)	(4)	5.46	62	2.78	32	--		.03	.3	.44	5
(3)	(6)	3.81	52	3.07	42	--		.05	.7	.48	7
July 18-19											
Section 1	(9)	15.25	69	2.52	11	.38	2	.08	.4	3.76	17
Section 2	(7)	12.78	70	2.86	16	.36	2	.04	.2	2.05	11
Section 3 (1)	(3)	5.66	41	2.31	17	.27	2	.05	.4	5.19	38
(2)	(4)	7.93	46	3.13	18	.14	1	.02	.1	5.95	34
(3)	(6)	8.75	55	2.57	16	.14	1	.02	.1	4.16	26
August 14-16											
Section 1	(9)	8.09	29	6.92	25	1.27	4	.20	1	4.00	14
Section 2	(7)	7.22	34	5.86	27	1.33	6	.24	1	1.47	7
Section 3 (1)	(3)	6.77	46	3.23	22	.61	4	.08	.5	1.84	12
(2)	(4)	6.20	43	3.80	27	.47	3	.11	1	1.60	11
(3)	(6)	7.94	48	3.92	24	.53	3	.08	.5	1.55	9
September 10-11											
Section 1	(7)	6.50	62	2.74	26	.04	.4	.11	1	.02	.2
Section 2	(6)	5.17	54	2.25	24	.06	1	.07	1	.09	1
Section 3 (1)	(3)	4.82	47	1.86	18	.12	1	.07	1	.25	2
(2)	(4)	4.88	51	2.40	25	.08	1	.09	1	.17	2
(3)	(5)	4.87	49	2.75	28	.08	1	.09	1	.15	2

Table 8. (continued)

	Number of samples	Daphnia	% Total	Leptodora	% Total	Adult Mysis	Juvenile Mysis	Mysis % Total	Total Zooplankton	Total Biomass (excluding Mysis) (gm/l x 10-5)
March 27-29										
Section 1	(10)	0	0	0	0	0	0	0	1.79	.26
Section 2	(3)	0	0	0	0	0	0	0	1.96	.29
Section 3 (1)	(5)	.005	.2	0	0	0	0	0	2.81	.53
(3)	(2)	.005	.1	0	0	0	0	0	3.82	.72
May 2-4										
Section 1	(9)	.002	.06	0	0	0	0	0	3.39	.61
Section 2	(6)	.003	.1	0	0	0	0	0	3.28	.59
Section 3 (1)	(3)	0	0	0	0	0	.0014	.1	1.97	.35
(2)	(3)	.001	.03	0	0	.0002	0	.01	3.02	.54
(3)	(4)	0	0	0	0	.001	0	.02	5.07	.91
May 30-June 1										
Section 1	(9)	.003	.04	0	0	0	0	0	6.39	1.47
Section 2	(7)	.002	.03	0	0	0	0	0	5.81	1.22
Section 3 (1)	(3)	.003	.2	0	0	0	.0006	.03	1.78	.45
(2)	(4)	.003	.1	0	0	0	.00005	.002	3.09	.80
(3)	(5)	.005	.1	0	0	.0004	0	.01	4.20	1.09
June 19-20										
Section 1	(9)	.02	.1	0	0	0	0	0	14.98	3.29
Section 2	(7)	.002	.02	0	0	0	.0012	.01	11.44	2.06
Section 3 (1)	(3)	.008	.2	0	0	.0003	.0009	.03	3.34	.84
(2)	(4)	0		0	0	.00005	.0004	.0005	8.74	1.57
(3)	(6)	.004	.05	0	0	0	.0006	.001	7.35	1.32
July 18-19										
Section 1	(9)	.26	1	-	-	0	0	0	22.14	5.34
Section 2	(7)	.27	1	-	-	0	0	0	18.32	4.39
Section 3 (1)	(3)	.10	1	-	-	0	0	0	13.61	3.13
(2)	(4)	.15	1	.001	-	0	0	0	17.38	4.17
(3)	(6)	.13	1	present	-	0	0	0	15.85	3.96
August 14-16										
Section 1	(9)	7.57	27	.004	.01	0	0	0	28.07	7.86
Section 2	(7)	5.45	25	.002	.01	0	0	0	21.53	6.46
Section 3 (1)	(3)	2.29	15	.009	.1	0	0	0	14.85	4.15
(2)	(4)	2.02	14	.01	.1	0	0	0	14.28	3.99
(3)	(6)	2.35	14	.007	.04	0	0	0	16.40	4.59
September 10-11										
Section 1	(7)	1.11	11	-		0	0	0	10.52	2.81
Section 2	(6)	1.56	16	.00016	.002	0	0	0	9.53	2.76
Section 3 (1)	(3)	3.04	30	.0008	.001	0	0	0	10.18	3.05
(2)	(4)	2.00	21	-		0	0	0	9.39	2.79
(3)	(5)	1.90	19	.00065	.001	0	0	0	9.85	2.95

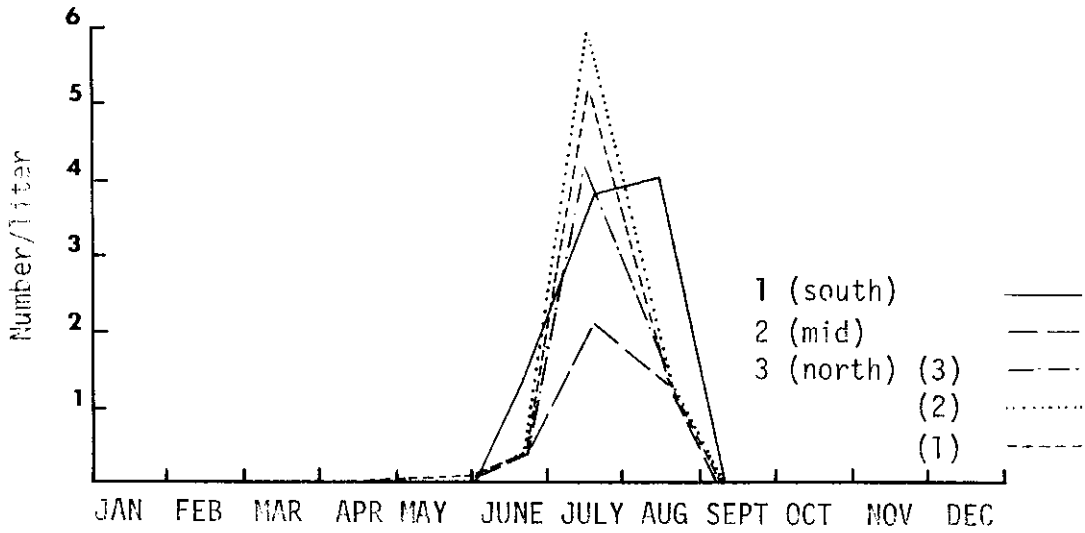

Figure 26. Mean Bosmina numbers in Pend Oreille Lake, Idaho, 1974.

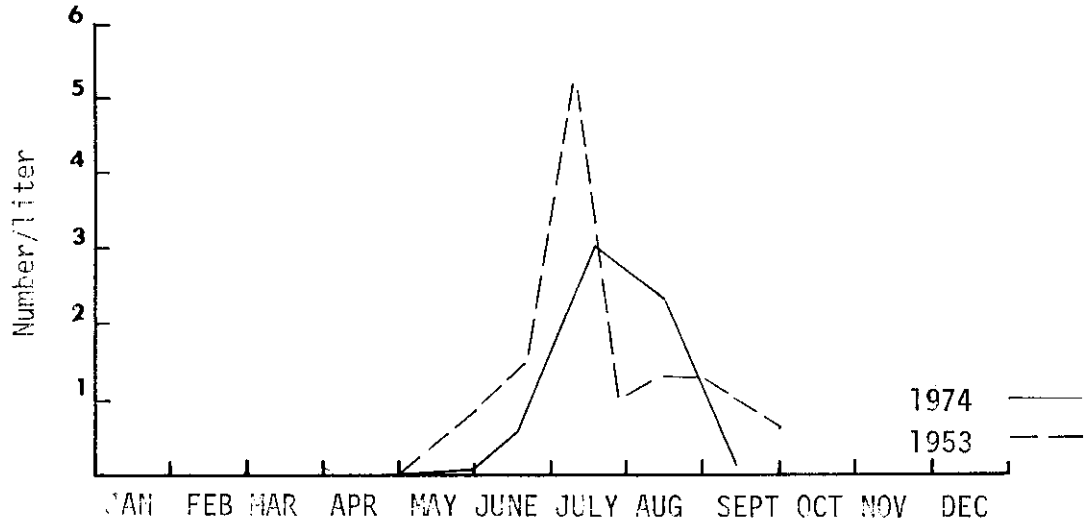

Figure 27. Mean Bosmina numbers for Pend Oreille Lake, Idaho, 1953-1974.

Bosmina became established as an open water form sometime between 1923, when it was nonexistant as a limnetic form, and 1953 when it was an important component of the zooplankton. It is the only "new" zooplankton since that time other than Mysis which was introduced by the Idaho Department of Fish and Game.

Bosmina is the smallest individual in the macrozooplankton community. Its importance as a kokanee food item is unclear.

Epischura

Epischura was not numerically important. It was not recorded until June. Standing crops were highest in the southern areas (Figure 28). Two peaks in abundance were observed, one in June and a second in August. Maximum mean section density ranged from .25 Epischura/liter in section 1 to .08/liter in section 3(1). A maximum density of .46 Epischura/liter was found in an August sample from section 2.

Epischura was not reported numerically in 1954.

Although Epischura was not numerically important its large size may make it important in the kokanee diet.

Leptodora

Leptodora, a very large predaceous Cladoceran, was not present in samples until July. Densities were never high (Table 8). The maximum density recorded was .01 Leptodora/liter from section 3(2) in August.

Only 1 Leptodora was captured in the entire 1954 study. This may not represent an actual increase in the lake population since the Wisconsin type net, used in 1954, may be avoided by the large plankter.

The large size of Leptodora may make it an important kokanee food item despite its low densities.

Mysis

Mysis was captured in daytime samples in February, May and June. Free swimming juveniles were present in samples in May and June. The Mysis were captured in daylight samples only in turbid waters. No Mysis were collected during the day in section 1. The highest density

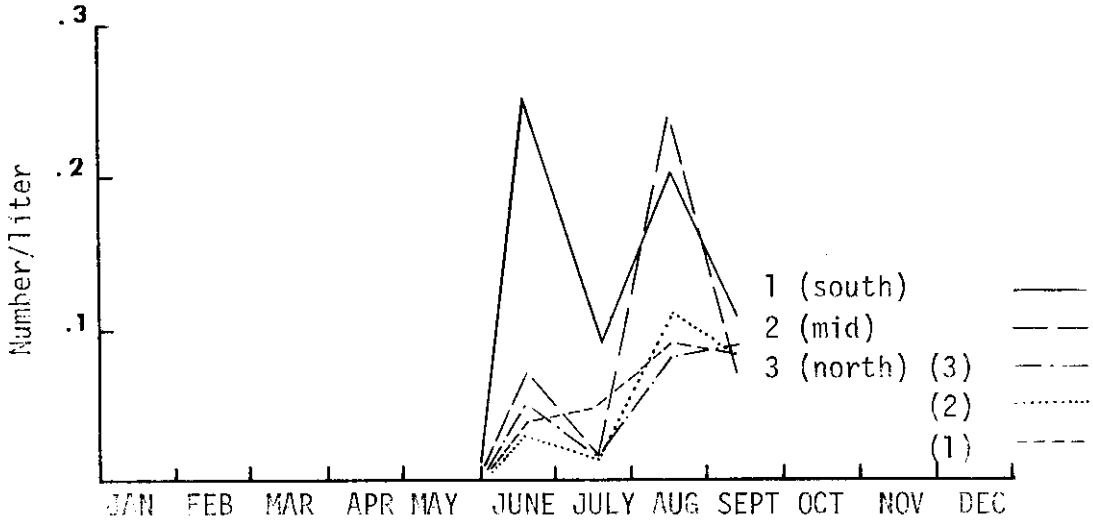

Figure 28. Mean Epischura numbers in Pend Oreille Lake, Idaho, 1974.

of Mysis found during the day was .004 individuals/ in May. All Mysis collected in daytime tows were young-of-the-year If included with the total zooplankton, Mysis would have comprised approximately 10% of the total dry weight biomass.

Beginning in June, night samples were taken in Idlewild Bay (south end of the lake) each month. Mysis was found at densities of .020 individuals/ liter and .023 individuals/liter for June and July, respectively. The samples were approximately 95% young-of-the-year If included with the total zooplankton the Mysis would have comprised approximately 14% of the total dry weight biomass. Very few Mysis were collected in August. Trermal stratification may have prevented extensive migration of Mysis into the upper 46 m l a y e r No Mysis were collected in September or October.

Mysis was first introduced into Pend Oreille in 1966. Fish and Game data suggests that populations are still developing in the lake.

The impact of Mysis on the ecology of the zooplankton community is unknown. Mysis is apparently isolated from the largest part of the zooplankton during summer stratification (August, September). Ag this time Mysis does not occur regularly above 46 m t h i s isolation may reduce interaction with other zooplankton in late summer. It may also reduce the availability of Mysis to fish populations.

Mysis has not been included in total zooplankton estimates. The two-year generation time and sporadic occurrence in the upper 46 m makes standing crop estimation and interpretation difficult. However, it must be noted that the inclusion of Mysis would make a substantial increase in the level of secondary production. Mysis may quite possibly exploit a new niche in the deeper waters of Pend Oreille, utilizing settling detrimental materials from the more productive upper waters. Mysis stomach analysis revealed organic debris, diatoms and crustacean appendages.

Some workers have suggested that Mysis introductions may result in changes within the zooplankton community. Zyblut (1970) felt that Mysis introductions in Kootenai Lake may have been a factor in reduced Daphnia populations. Such a change in the zooplankton community might adversely

affect the kokanee population. In many lakes Daphnia is the major kokanee food item. Lewis (1972) has shown that the October mean length of age I kokanee in Odell Lake, is highly correlated to the summer standing crop of Daphnia.

Young kokanee may be especially dependent upon a particular zooplankter. Because of their size the small fish may be incapable of utilizing Mysis as a food item. Suppression of a particular portion of the zooplankton community by Mysis introductions could result in reduced survival of young fish.

In Pend Oreille Mysis introductions may not have had an important affect on the zooplankton community. The actual impact of Mysis introductions would depend on the species making up the zooplankton community, the morphology of the lake, and the food habits of the fish present.

Vertical distribution of zooplankton

A diurnal series of zooplankton samples was taken on 16 July. Whole water samples were taken from seven depths to 50 meters and strained through a #10 net. Zooplankton from each sample were enumerated to describe the vertical distribution over a 24-hour period (Figure 29).

Only 3 genera; Bosmina, Cyclops and Diaptomus were present in significant numbers. Only 12 Daphnia were captured. All but one Daphnia were found at or above 12 m (40'). Both Cyclops and Bosmina show vertical migration, perhaps related to light intensity. The pattern of Diaptomus migration was complicated by differing responses of juveniles and adults?

Virtually the entire sample of individuals was above 30 m (100'). during daylight hours. A second set of vertical distribution samples collected in September but has not yet been analysed. In 1975, we would like to obtain vertical distribution information down to 1000 feet.

DISCUSSION:

Pend Oreille is still an oligotrophic lake of the nature described by Stross in 1954, and available information indicates little change from the lake described in 1923 by Kemmerer.

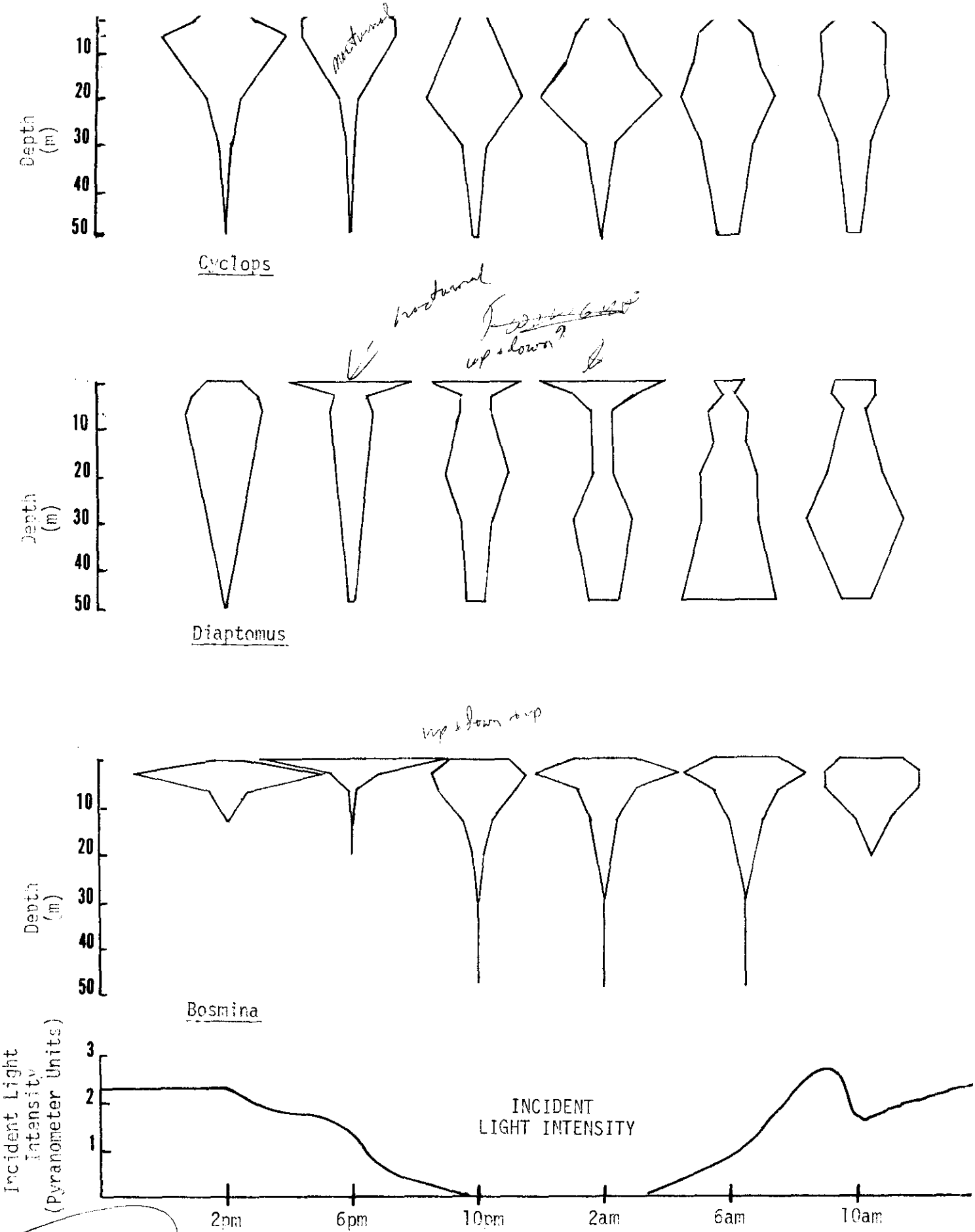

Figure 29. Vertical distribution of Bosmina, Diaptomus, and Cyclops by relative proportion of population; and light intensity in Pend Oreille Lake, 2-3 July 1974.

Limnological trends were similar in 1953 and 1974. However, 1974 was a cooler water year, and most parameters (common to both years) indicate that the lake had higher and more prolonged levels of primary production in 1974. We do not know yet if this reflects the range of year to year fluctuation in conditions or an actual upward trend in the productivity of the lake.

Although the overall conditions in the lake have not changed drastically, some interesting changes are obvious in the zooplankton community. We feel that these changes may be directly related to the kokanee population for several reasons. First, Bosmina has become established as an open water plankter sometime between 1923, when it was absent as a limnetic form, and 1953 when it was an important component of the zooplankton community. It was during the same time period that kokanee became established in the lake. Second, the 1953 dominance of Bosmina has yielded to a 1974 dominance of Daphnia. At the same time, a decline in kokanee harvest has taken place. Finally, in 1974 the differences in relative importance of Bosmina and Daphnia appear to be correlated with the relative distribution of kokanee throughout the lake. It appears that selective kokanee grazing on Daphnia may have given Bosmina a competitive advantage during the years of high kokanee populations.

Our conclusion is that the level of the kokanee population is reflected directly in zooplankton composition. Moreover, the level of "selective predation" of kokanee upon the larger Daphnia may indirectly regulate the competitive advantage of Bosmina. Increases or decreases in the kokanee population result in the co-fluctuation of the two cladocerans. This hypothesis is similar to that proposed by Brooks and Dodson (1965) and the phenomena discussed by Hrbacek et al. (1961) and Allan (1974).

The Clark Fork River is a major influence in the lake system. The Clark Fork inflow has profound effects on the primary and secondary production in the lake by regulation of the nutrient load, turbidity, and flushing time. As the major source of water to the lake any changes

in the river and its watershed will undoubtedly be reflected in the lake. The future of Pend Oreille is directly tied to water development and pollution load of the Clark Fork River.

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JOB PERFORMANCE REPORT

State of Idaho | Name: LAKE AND RESERVOIR INVESTIGATIONS

Project No. F-53-R-10 | Title: Lake Pend Oreille Kokanee Life History Studies

Job No. IV-e

Period Covered: 1 March 1974 to 28 February 1975

ABSTRACT:

During 1974 a monthly echosounding survey was completed on Pend Oreille Lake to assess fish abundance and movement. We used vertical gill nets to determine fish species and age class composition, and food habits of the kokanee in the lake. A small trawl was used to evaluate the densities and distribution of Mysis relicta in the lake.

The population estimates for the lake in 1974 showed a trend of in-creasing fish abundance from 4.6 million in January to 11.7 million fish in March. The estimate stabilized at an average of 11. 8 million fish from March through September and dropped to an average of 8.4 million for October, November and December when kokanee commenced spawning. Specific fish distribution and movement patterns were difficult to assess suggesting that there was continual fish movement throughout the lake especially from March through September.

Gill netting from May through October yielded 95.7% kokanee of the total fish collected. Kokanee age classes included age 1+, 2+, 3+ and 4+ fish. A majority of the age 1+ kokanee collected in the gill nets were taken from the north end of the lake. Daphnia sp. was the dominant food item in the kokanee diet during August and September. No Mysis shrimp were found in any of the stomachs examined.

Mysis shrimp densities have increased in Pend Oreille Lake from 0.1 mysids per m^3 in 1972 to 1.2 mysids m^3 in 1974. Evidence from the food habits of kokanee in Priest Lake, Idaho indicate that Pend Oreille Lake kokanee have not attained an adequate size to begin actively feeding on Mysis.

Author:

Bert Bowler
Senior Fishery Research Biologist

RECOMMENDATIONS :

I. Continue to monitor fish abundance in Pend Oreille Lake with echo-sounding on a monthly schedule.

2. Employ the use of a data collection system (more sophisticated echo-sounding equipment) to check the accuracy of the quantitative measurements made by the present system and collect some target strength analysis information.

3. Program the present and future population estimate data for computer analysis of the estimates as well as their respective confidence intervals.

4. Evaluate the feasibility of operating the midwater trawl on Pend Oreille Lake as a more efficient method of fish collection than vertical gill nets for gathering species composition information, kokanee stomachs for food habit analysis, and collecting age 0 kokanee.

5. Begin collecting length and weight measurements, scale samples, otolith samples, stomach samples and egg skeins from kokanee taken in the angler catch from the north and south end of Pend Oreille Lake. The otolith and scale samples will be useful in assessing the age composition of the angler catch and growth rates. Egg skeins will be helpful in assessing age at maturity and fecundity.

6. Continue to trawl for Mysis relicta in Pend Oreille Lake for abundance and distribution evaluation and assess any utilization of shrimp by kokanee.

7. Begin to correlate fish population information with limnological data collected on the lake.

OBJECTIVES:

To assess fish densities and movement for Lake Pend Oreille by area and by season.

To determine species and age class composition of the Pend Oreille Lake fish population by season.

To determine the feeding habits of kokanee by year-class.

To evaluate the survival and distribution of Mysis relicta in Lake Pend Oreille.

INTRODUCTION:

The primary objective of the Pend Oreille Lake studies is assessment of the kokanee population in the lake. Parameters influencing population abundance or stock density include basic productivity of the water, growth, production, mortality (natural and fishing), spawning escapement, survival, and

recruitment of new fish to the population (Fig. 1). Through a program of limnological studies, echosounding, age and growth analysis, and angler harvest and opinions, we hope to gain more knowledge about kokanee population dynamics in Pend Oreille Lake for development of alternatives to managing the kokanee fishery in the lake.

TECHNIQUES USED:

Echosounding

To assess relative densitites and movement patterns of fish in Pend Oreille Lake during January through December of 1974, echosounding was used. We used a Ross Fineline 200 A depth sounder (105 kHz) with a hull mounted transducer (22° beam angle) fixed in a 6.4 m (21 ft) fiberglass boat.

All of the echosounding for fish population measurements was done at night and during the dark phase of the moon primarily for better interpret-ability of the echograms. During the daylight hours, the fish tended to school and could not be separated as individual fish targets on the echograms (Fig. 2). At night, in the absence of light, the fish schools dispersed allowing for the individual fish targets to be counted from the echograms depending on their relative densities (Figs. 3 and 4).

For sampling purposes, Pend Oreille Lake was divided into seven stratified sections. Each section was further divided into 804.9 m (0.5 mi) squares or grids called transects (Fig. 5). Each month of 1974 (except June) approximately 22% of the possible transects in each lake section were selected at random for echosounding (Table 1). We tranversed through the transects using known boat speeds, compass headings and fixed landmarks in each section of the lake. The average boat speed measured 2.4 m/sec (5.5 mph) at 1,000 rpm for echoshounding each transect and 12.2 m/sec (27 mph) at 3,500 rpm for traveling between transects.

The total fish estimates were made by calculating the mean number of fish (from the echograms) found in the volume of water sampled with the cone at 5 fathom (30 ft) intervals and expanding the value to the total volume of water in the lake to the depth at which fish were recorded on the echograms. The actual cone volume was computed from the 22° beam angle as the volume of a trapezoid (Fig. 6). No estimates were made above the 2 fathom (12 ft) level.

During the echosounding surveys the following settings were used on the depth sounder: short pulse length, fineline setting of 4, range selector 0 to 50 fathoms (1 fathom=6 ft), paper speed of 4 (equivalent to 2.54 cm or 1 in per minute), and a sensitivity or gain setting of 7. A gain setting of 7 allowed for the best resolution of fish targets found in the depth range at which kokanee were believed to be found (0 to 46 m; 0 to 150 ft) as assessed by gill netting (Fig. 7). A gain setting of 9 enables us to distinguish fish targets to a depth of 91 m (300 ft) in the 0-50 fathom range but with that high of a sensitivity setting, it was difficult to distinguish single fish targets from 0 to 46 m (0 to 150 ft) because of noise interference (Fig. 7).

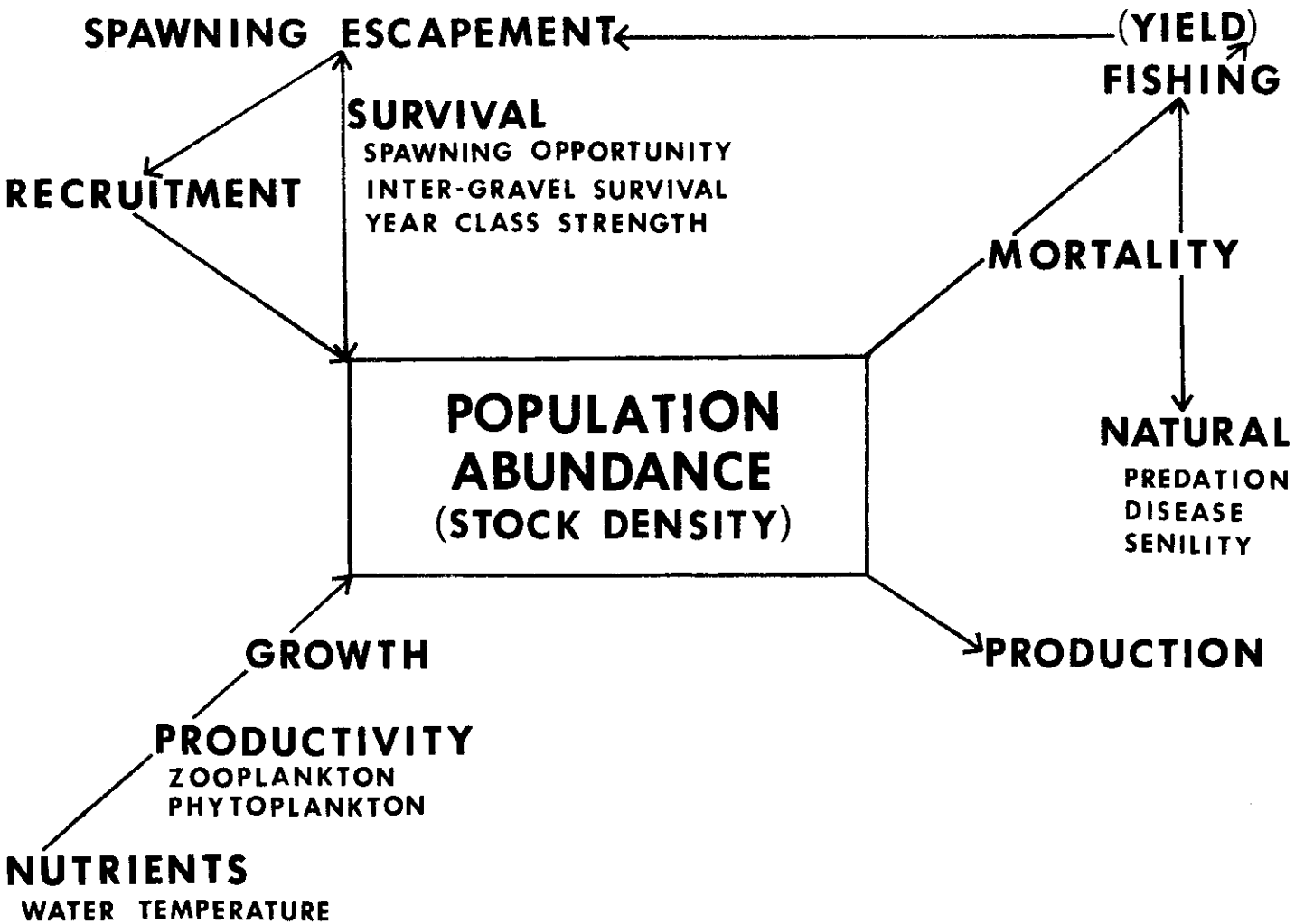

Figure 1. Diagram of parameters influencing the population abundance (stock density) of kokanee in Pend Oreille Lake.

Figure 2. Echogram depicting a typical daytime distribution of fish targets in Pend Oreille Lake (recorded by echosounding in December 1973). Note the clumping (fish schools) between 10 and 15 fathoms on the echogram.

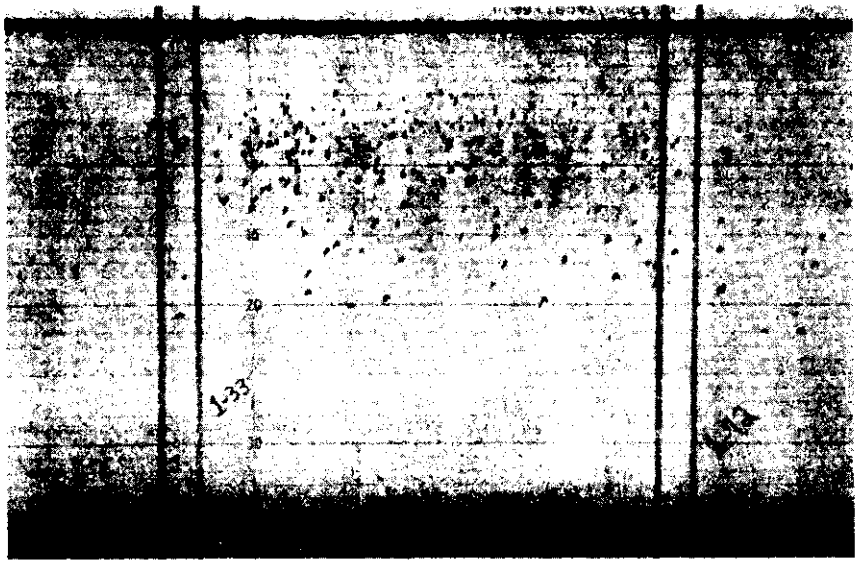

Figure 3. Echogram depicting a typical night distribution of fish targets in Pend Oreille Lake (recorded by echosounding in December 1974). Note the separation of individual fish targets which allow for relatively accurate enumeration. The distance between paper marks on the echogram is equivalent to one transect (804.9 m; 0.5 mi).

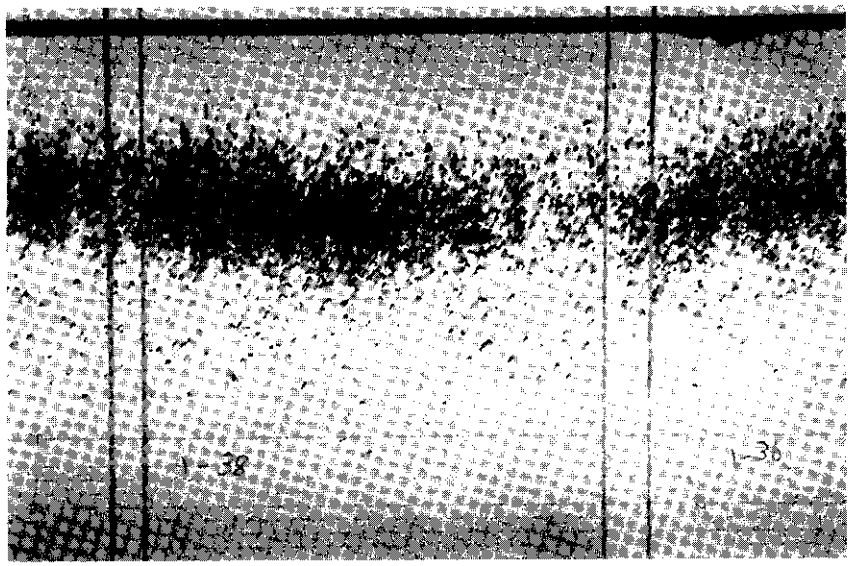

Figure 4. Echogram depicting a typical night distribution of fish targets in Pend Oreille Lake in the extreme south end of the lake during January (recorded by echosounding in January 1975). Note the overlapping fish targets which reduced the accuracy of fish enumeration. The distance between paper marks on the echogram is equivalent to one transect (804.9 m; 0.5 mi).

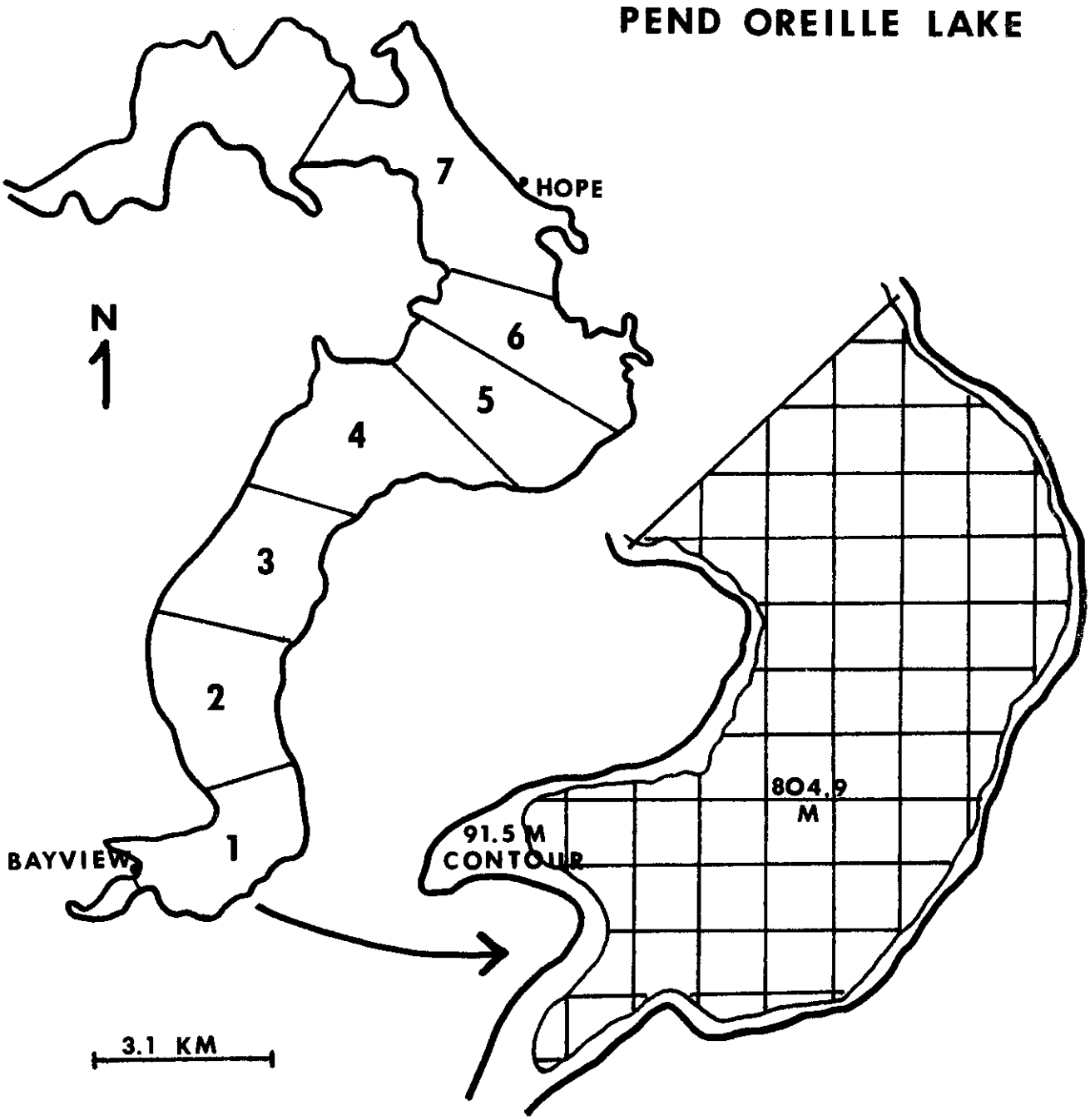

Figure 5. Stratified sampling sections used on Pend Oreille Lake during the 1974 echosounding survey. Each lake section was divided into 804.9 m (0.5 mi) transects.

Table 1. The total number of possible echosounding transects by lake section in Lake Pend Oreille and the number and percent that were sampled monthly in 1974.

Section	Total Transects	Transects Sampled	Percent
1	90	20	22.2
2	91	20	22.0
3	107	23	21.5
4	110	23	20.9
5	102	22	21.6
6	64	14	21.9
7	69	15	21.7
Total	633	137	21.6

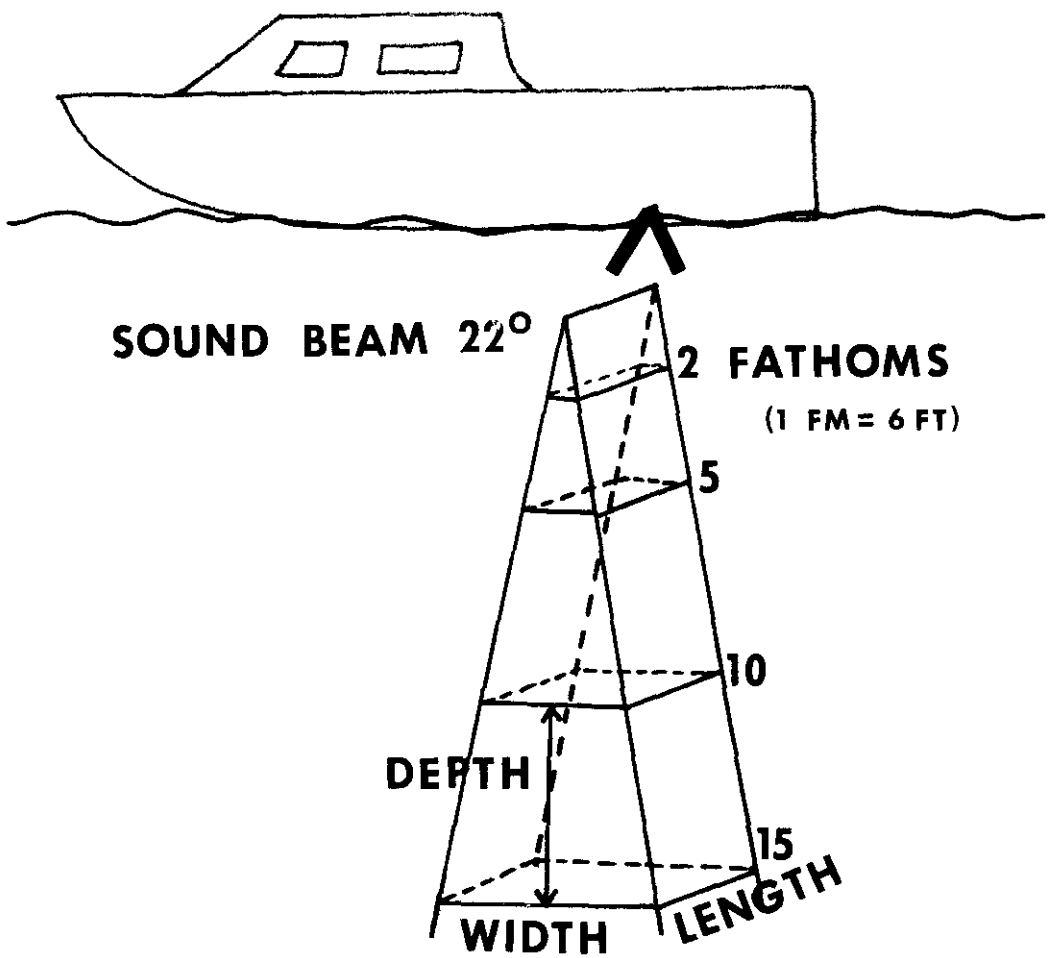

Figure 6. Calculation of cone volume by computing the volume of a trapezoid derived from a beam angle of 22°. This method was used in calculating fish population estimates in Pend Oreille Lake during 1974.

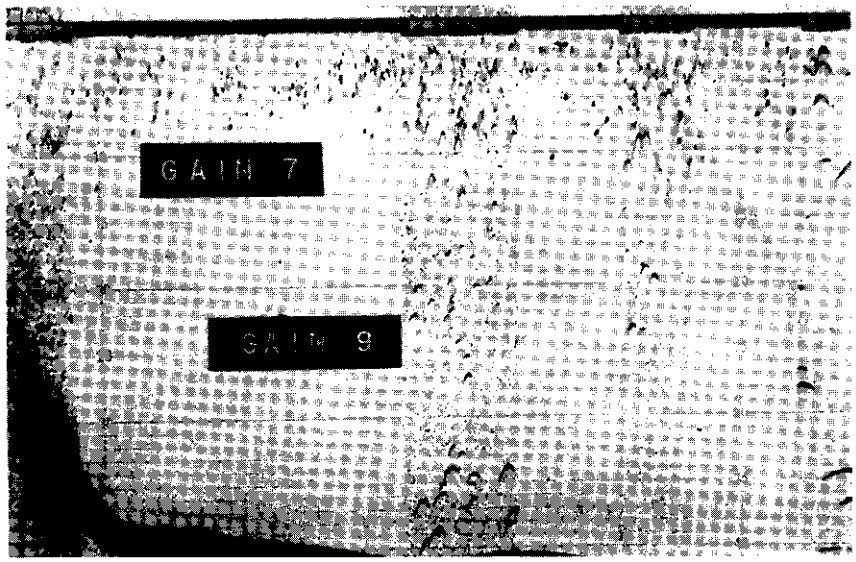

Figure 7. Echogram depicting the difference in recorded fish targets at two different gain settings. Note that with a gain of 7 individual targets are recorded in the upper layers of the water column and with a gain of 9 fish targets are recorded in the lower layers of the water column with those targets in the upper layers being masked by noise interference.

Gill Netting

We used vertical gill nets to collect fish for assessing the species composition of the fish populations located by echosounding in Pend Oreille Lake in 1974. We also collected otolith bones and stomachs from the kokanee caught in the nets for age, growth, and food habit analysis.

Twelve vertical gill nets were used. The nets measured 30.5 m (100 ft) in length and 1.8 m (6 ft) in width and were attached to PVC pipe filled with styrofoam to keep them afloat. The nets were also equipped with a spreader bar located every 7.6 m (25 ft) along the length of the net to keep them from folding in the center. All nets were divided equally among stretch mesh sizes of 2.54 cm (1 in), 3.81 cm (1.5 in) and 5.08 cm (2 in). Each net was designed specifically to hang vertically on a 0.5 basis.

We set gill nets from May through October of 1974 in all sections of the lake. To increase the netting efficiency, we fished the nets through all hours of darkness during the period in which we were netting.

Angler Catch

We collected kokanee stomachs from the angler catch primarily to assess the difference in loss and decomposition of food organisms from stomachs taken in the catch compared to those taken in the gill nets.

Shrimp Trawling

To evaluate the abundance and distribution of Mysis relicta in Pend Oreille Lake, we made nine trawls throughout the lake in June of 1974. The shrimp trawl was constructed of nylon bobbinetting with an opening of 55.9 cm (22 in) x 147.3 cm (58 in). The net was towed during the hours of darkness for a 10-minute interval at approximately 7.6 m (25 ft).

FINDINGS :

Fish Densities, Distribution and Movement

Monthly fish population estimates obtained from echosounding from January through December 1974 are shown in Table 2. An estimate was not made in June because of the large amount of floating debris on the lake which made night sounding hazardous.

The population estimates depict a trend of increasing fish abundance from January through March with a stabilizing period from March through September and then a drop from October to December (Fig. 8). The low population estimate in July was attributed to a malfunction in the echosounding equipment.

By comparing the fish population estimates in each section of the lake from month to month (Table 2), it was difficult to assess any definite movement patterns. It appears that the fish were generally distributed throughout the lake with continual movement. There was very little consistency in estimated numbers of fish in the same sections from month to month (Table 2).

Table 2. Monthly fish population estimates and densities by lake section obtained from echosounding data in Pend Oreille Lake in 1974.

	January		February	
Sect.	Total	Fish/10,000 m^2	Total	Fish/10,000 m^2
1	1,382,830	436.7	1,236,328	390.5
2	157,671	47.5	1,456,751	438.8
3	266,476	71.2	1,134,544	303.4
4	165,178	40.9	1,215,862	301.2
5	1,866,471	553.3	1,877,983	556.7
6	713,127	310.3	709,384	308.6
7	134,477	49.6	613,490	226.2
Total	4,586,230	1,509.5	8,244,342	2,525.4

	March		April	
Sect.	Total	Fish/10,000 m^2	Total	Fish/10,000 m^2
1	1,042,294	392.2	1,563,183	493.7
2	2,422,086	729.5	2,128,985	641.1
3	2,679,072	716.4	1,204,414	322.1
4	2,439,703	604.4	2,254,947	558.6
5	1,174,970	348.3	2,263,026	670.9
6	707,197	307.7	666,356	289.9
7	1,276,772	470.7	1,820,789	671.3
Total	11,742,094	3,569.2	11,901,700	3,647.7

Table 2. Monthly fish population estimates and densities by lake section obtained from echosounding data in Pend Oreille Lake in 1974 (continued).

	May		June
Sect.	Total	Fish/10,000 m^2	No Estimate Made
1	1,259,490	397.8	
2	953,578	287.2	
3	3,296,710	381.6	
4	2,343,298	580.5	
5	1,633,440	484.2	
6	1,020,670	441.1	
7	1,232,946	454.6	
Total	11,740,132	3,527.0	

	July		August	
Sect.	Total	Fish/10,000 m^2	Total	Fish/10,000 m^2
1	2,086,196	658.9	2,108,589	666.0
2	1,099,430	331.1	1,413,430	425.7
3	1,185,425	317.0	1,445,811	386.6
4	983,534	243.6	1,471,534	364.5
5	660,388	195.8	1,823,136	540.5
6	286,848	124.8	1,358,074	590.9
7	693,951	255.8	1,993,860	735.1
Total	6,995,772	2,127.0	11,614,434	3,709.3

Table 2. Monthly fish population estimates and densities by lake section obtained from echosounding data in Pend Oreille Lake in 1974 (continued).

	September		October	
Sect.	Total	Fish/10,000 m^2	Total	Fish/10,000 m^2
1	1,281,470	404.7	2,285,804	721.9
2	1,317,126	396.7	1,297,017	390.7
3	1,347,064	360.2	1,270,657	339.8
4	1,883,371	466.6	1,377,716	341.3
5	2,468,463	731.8	973,483	288.6
6	1,372,565	597.2	659,289	286.9
7	2,196,084	809.6	819,082	302.0
Total	11,866,143	3,766.8	8,683,048	2,671.2

	November		December	
Sect.	Total	Fish/10,000 m^2	Total	Fish/10,000 m^2
1	2,280,763	720.3	1,022,614	323.0
2	1,115,712	336.0	1,643,341	495.0
3	540,687	144.6	1,231,925	329.4
4	730,965	181.1	1,525,756	378.0
5	1,351,458	400.6	1,072,435	317.9
6	885,614	385.3	935,415	407.0
7	1,636,925	603.5	693,925	255.8
Total	8,542,124	2,771.4	8,125,411	2,506.1

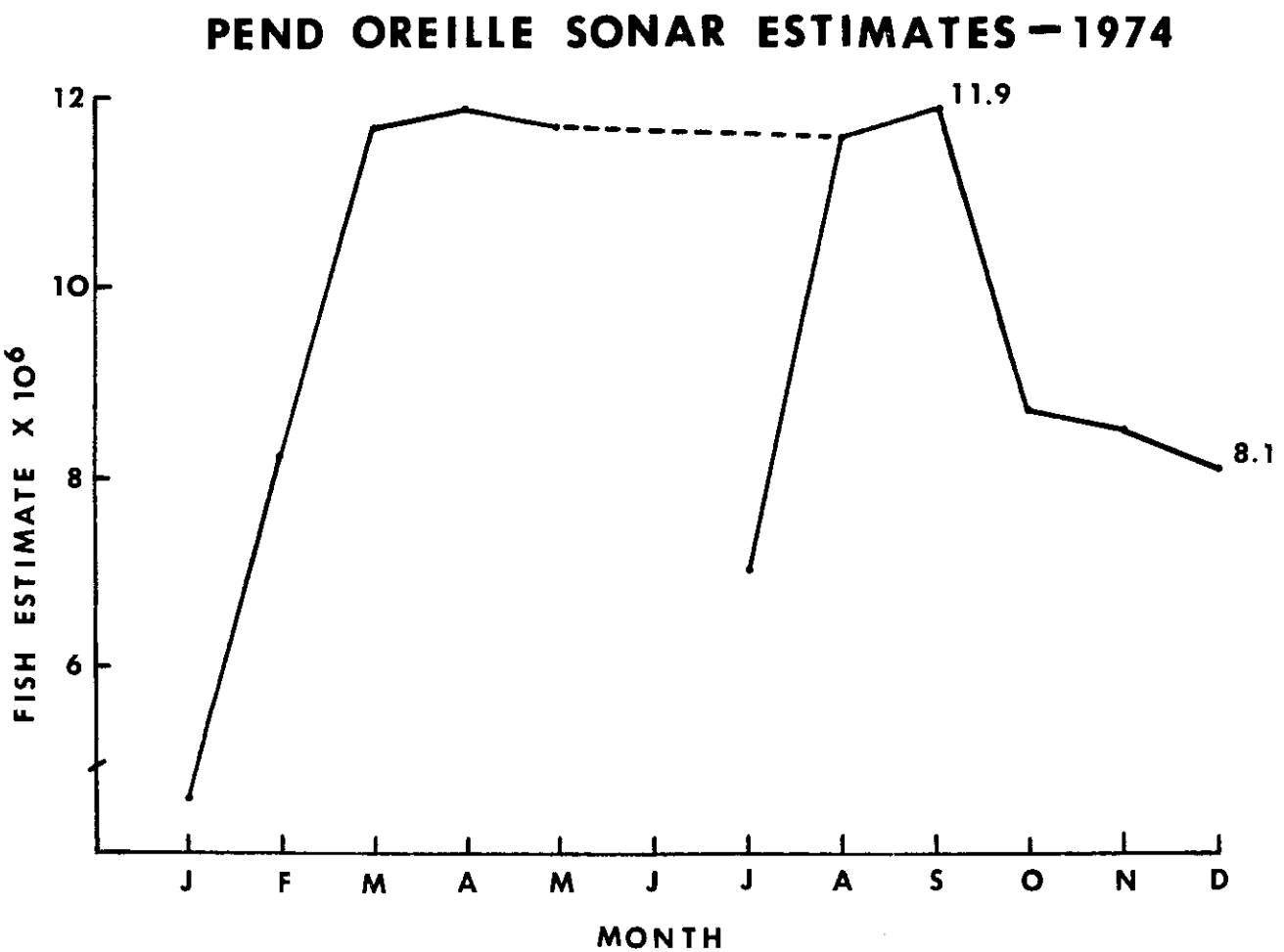

Figure 8. Monthly fish population estimates obtained from echosounding in Pend Oreille Lake during 1974.

The night vertical distribution of fish in Pend Oreille Lake during 1974 changed from month to month. The bulk of the fish generally remained close to 23 m (75 ft) in depth during January and February and began to ascend in the water column toward the surface from March through May as lake water temperatures began to rise (Fig. 9). Throughout the summer and fall when the lake waters became stratified, the fish descended in the water column until the fall over-turn occurred in early December when they ascended again (Fig.9).

Species Composition

Gill netting in Lake Pend Oreille from May through October of 1974 yielded 1,660 fish of which 1,589 were kokanee (75.77). A total of 219 net sets were made during that period for an average of 7.6 total fish per net set and 7.3 kokanee per net set. One net set was equivalent to one net fishing at least through the period of darkness during one 24-hour period or 1 day. Each net set was approximately 12 hours in duration.

Other species collected in the gill nets included redside shiner, perch, squawfish, mountain whitefish, lake whitefish, rainbow trout, cutthroat trout, and Dolly Varden (Table 3). The gill netting efficiency for kokanee began with 1.3 fish per net in May, peaked at 18.2 kokanee per net in August and dropped to 5.7 kokanee per net in October (Table 3).

Age Class Composition

Age class composition, by month, of the kokanee population sampled with gill nets in Pend Oreille Lake from June through October 1974 is described in Figs. 10, 11, 12, 13, and 14. The respective age classes, derived from length frequency histograms, include age 1+, 2+, 3+, and 4+ combined (Table 4). A majority of the age 1+ kokanee were collected from lake sections 5, 6, and 7 (north end) with the remaining age groups distributed relatively evenly through-out the lake (Figs. 10, 11, 12, 13, and 14).

The increment of growth for each age class of kokanee, also derived from length frequency histograms, is shown in Table 5. The average growth rate per month from June through October 1974 for each age class was 3.63 mm (.14 in) for age 1+, 5.27mm (.21 in) for age 2+ and 6.56 mm (.26 in) for age 3+ and 4+ combined (Table 5).

Kokanee Food Habits

We analyzed 656 kokanee stomachs taken in Pend Oreille Lake during the summer and fall of 1974. A total of 560 stomachs were collected from the gill net catch and 96 stomachs were taken from the angler catch. Of all the stomachs analyzed 255 (39%) were empty and 257 (397) contained identifiable organisms. Forty-five percent of the stomachs taken from the gill net catch were empty compared to only 1% empty stomaches taken from the angler catch. Thirty-one percent of the stomachs taken from the gill net catch contained identifiable organisms compared to 90% containing identifiable organisms from the angler catch (Table 6).

Bosmina sp. was the predominate food organism in the kokanee diet during June and July. A few Daphnia sp. and unidentifiable copepods were found in the

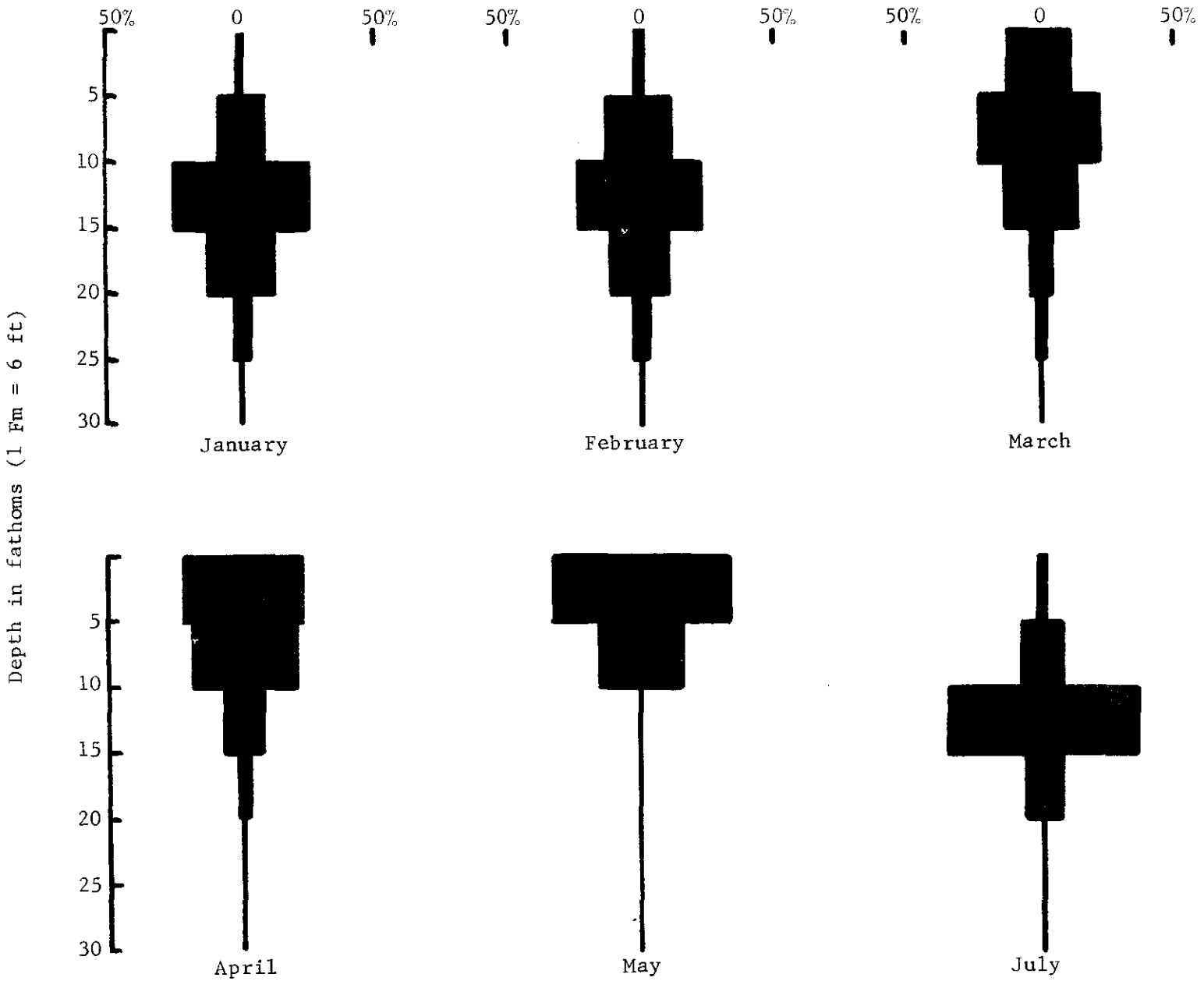

Figure 9. Seasonal (night) vertical distribution of fish (expressed as a % of the total trace count) in Pend Oreille Lake taken from echosounding data collected in 1974.

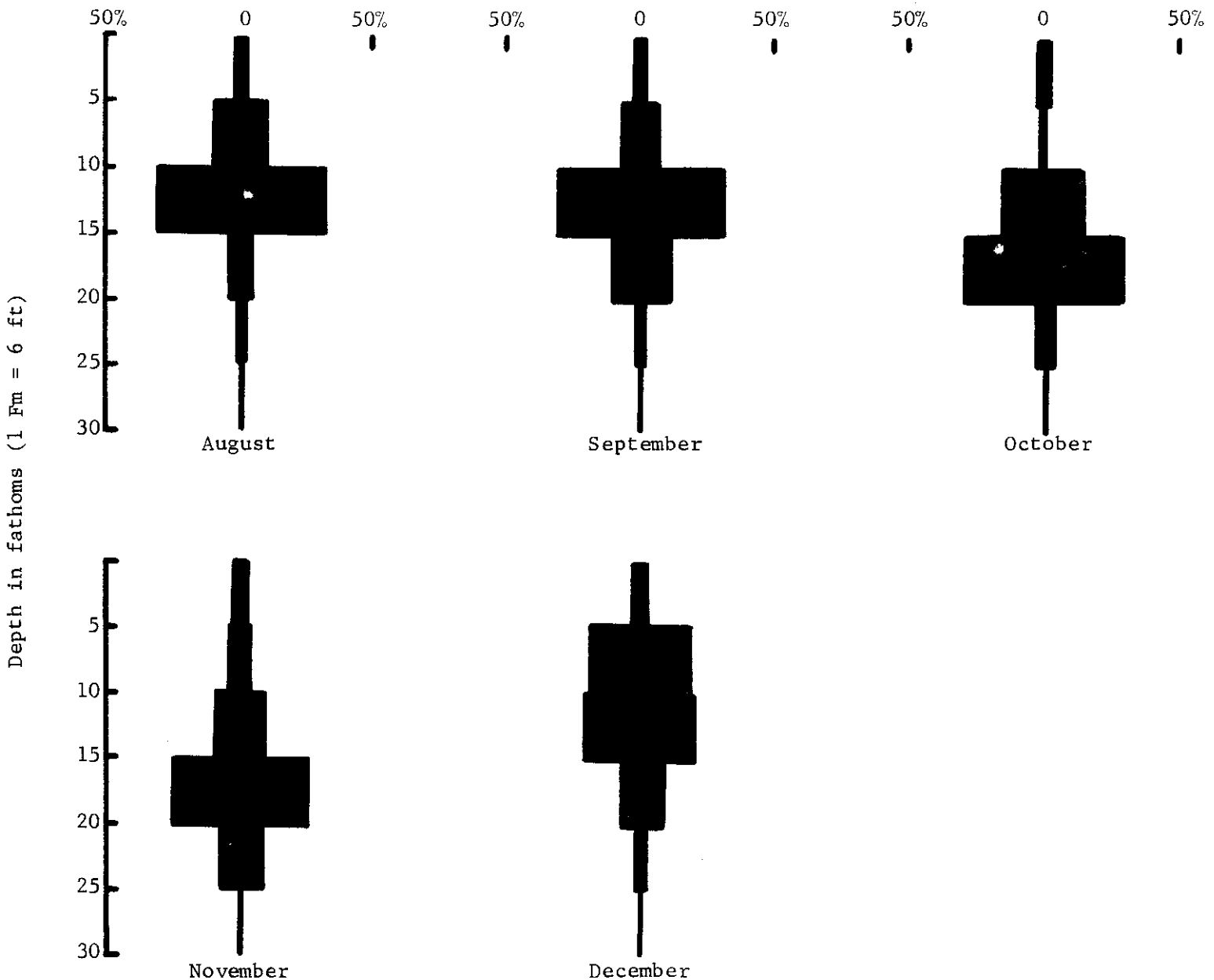

Figure 9. Seasonal (night) vertical distribution of fish (expressed as a % of the total trace count) in Pend Oreille Lake taken from echosounding data collected in 1974 (continued).

Table 3. Number and species of fish taken in vertical gill nets in Lake Pend Oreille from May through October 1974. Gill nets measured 30.5 m (100 ft) in length and were of stretch mesh sizes of 2.54 cm (1 in), 3.81 cm (1.5 in) and 5.08 cm (2 in).

Month	Net sets	Fish species	Total number	Kokanee per net	Length range (mm)
May	36	Kokanee	48	1.3	190-250
June	36	Kokanee	206	5.7	120-250
		Redside Shiner	26		102-125
		Squawfish	3		200-227
		Mountain Whitefish	1		263
		Perch	1		119
July	47	Kokanee	193	4.1	110-280
		Cutthroat Trout	4		184-291
		Rainbow Trout	3		120-329
		Mountain Whitefish	2		251-308
		Squawfish	2		230-258
		Redside Shiner	1		110
		Perch	1		191
Aug.	40	Kokanee	729	18.2	120-270
		Rainbow Trout	7		198-343
		Cutthroat Trout	3		222-252
		Mountain Whitefish	2		251-286
		Redside Shiner	2		103-125
		Lake Whitefish	1		139
		Dolly Varden	1		521
Sept.	30	Kokanee	242	8.1	120-270
		Cutthroat Trout	4		225-300
		Rainbow Trout	1		201
		Lake Whitefish	1		361
		Dolly Varden	1		699
Oct.	30	Kokanee	171	5.7	120-280
		Rainbow Trout	2		242-307
		Cutthroat Trout	1		242
		Squawfish	1		283
Totals	219			7.3	

Total Fish Species

Kokanee	1,589	Squawfish	6
Redside Shiner	29	Mountain Whitefish	5
Rainbow Trout	13	Lake Whitefish	2
Cutthroat Trout	12	Dolly Varden	2
		Perch	2

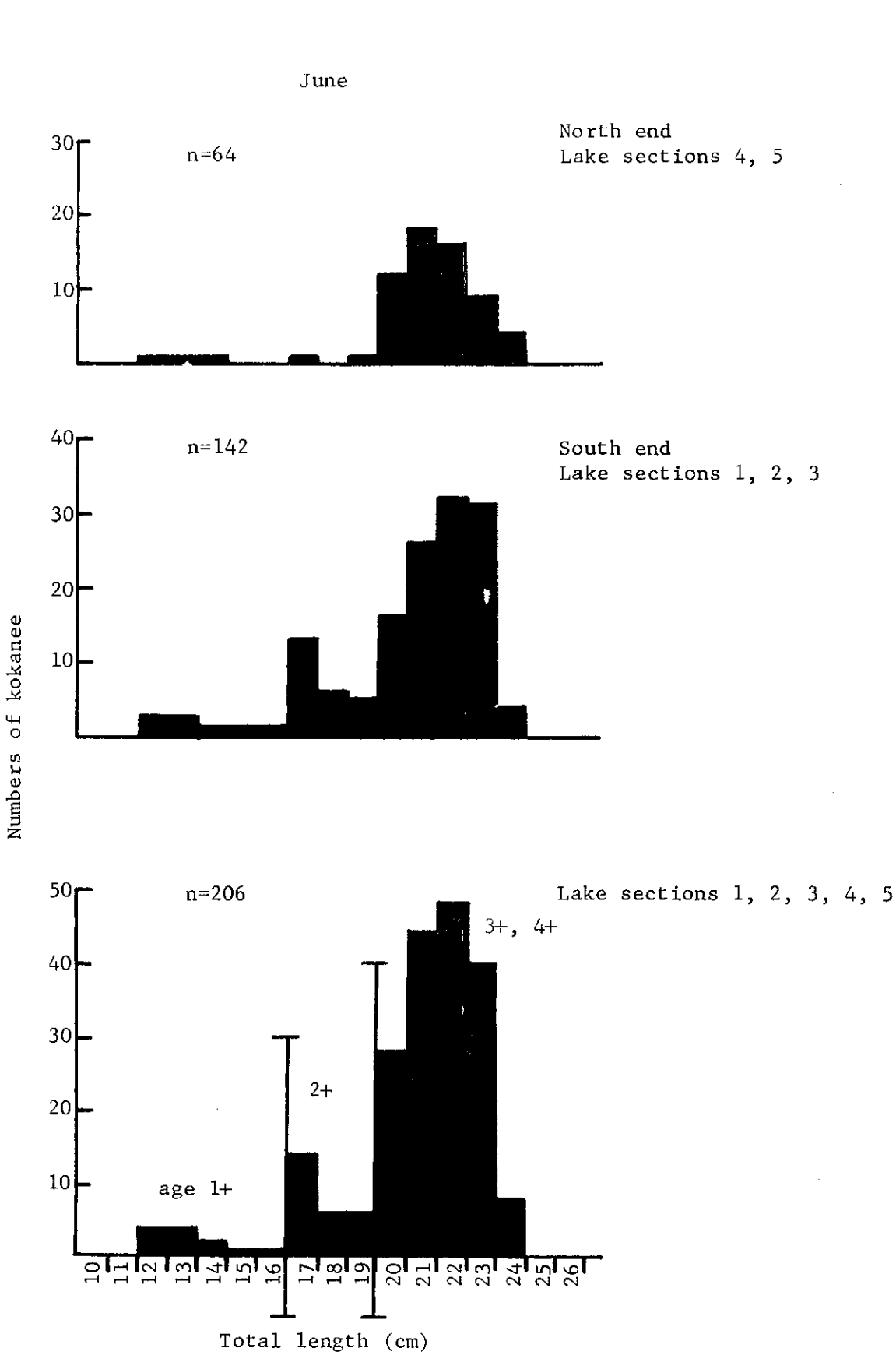

Figure 10. Length and age frequencies of kokanee collected from gill net catches in Pend Oreille Lake during June 1974.

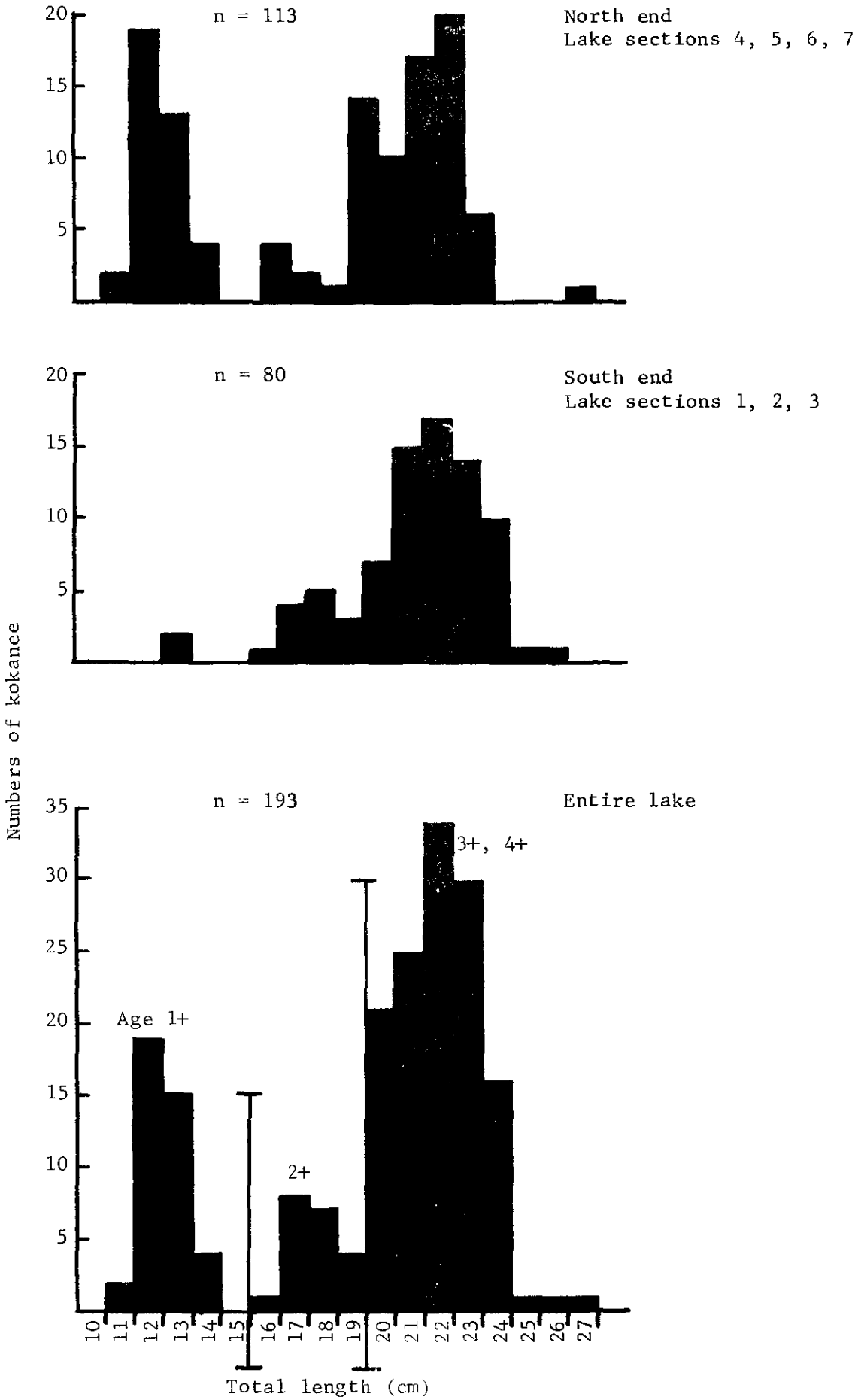

Figure 11. Length and age frequencies of kokanee collected from gill net catches in Pend Oreille Lake during July 1974.

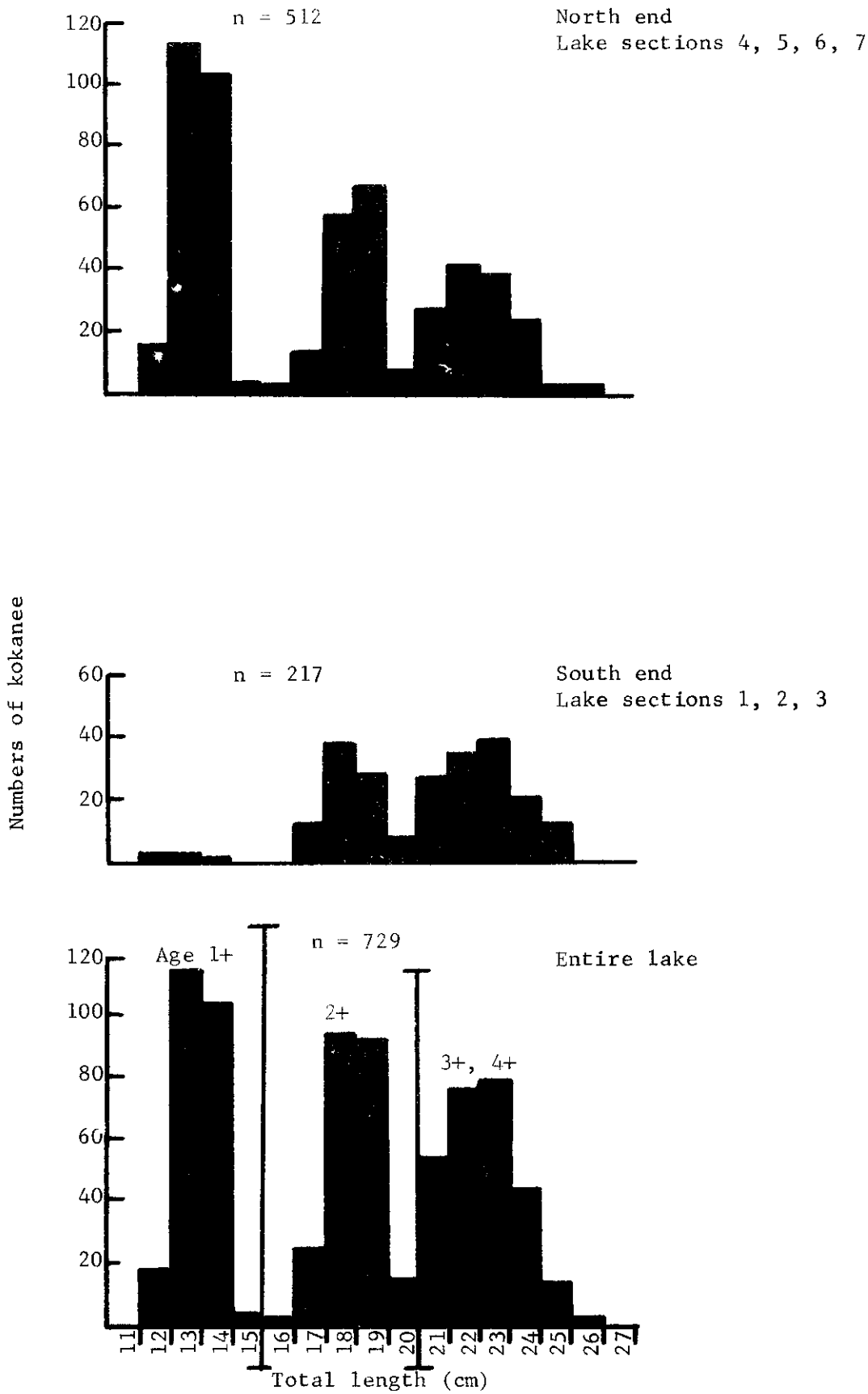

Figure 12. Length and age frequencies of kokanee collected from gill net catches in Pend Oreille Lake during August 1974.

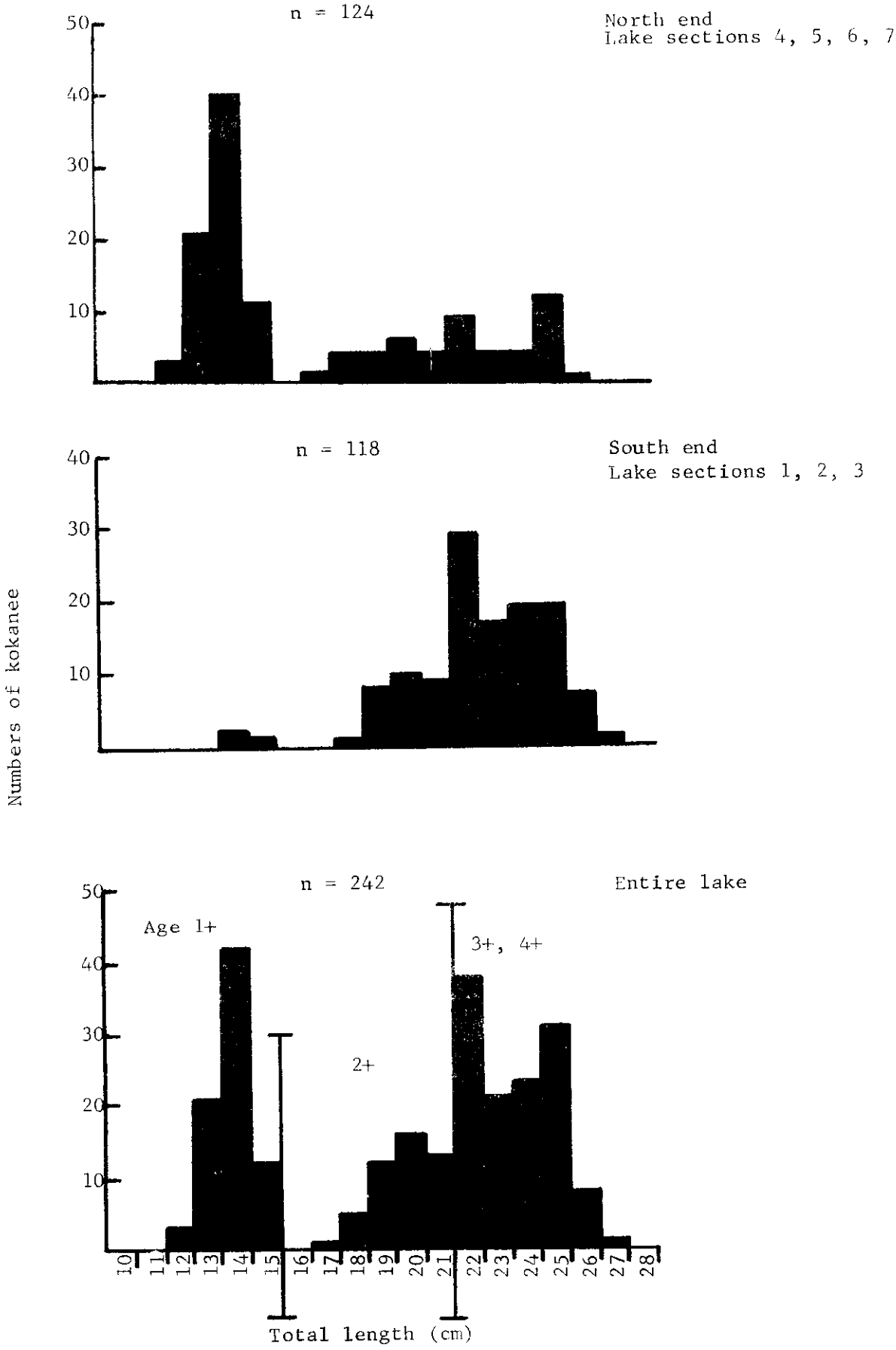

Figure 13. Length and age frequencies of kokanee collected from gill net catches in Pend Oreille Lake during September 1974.

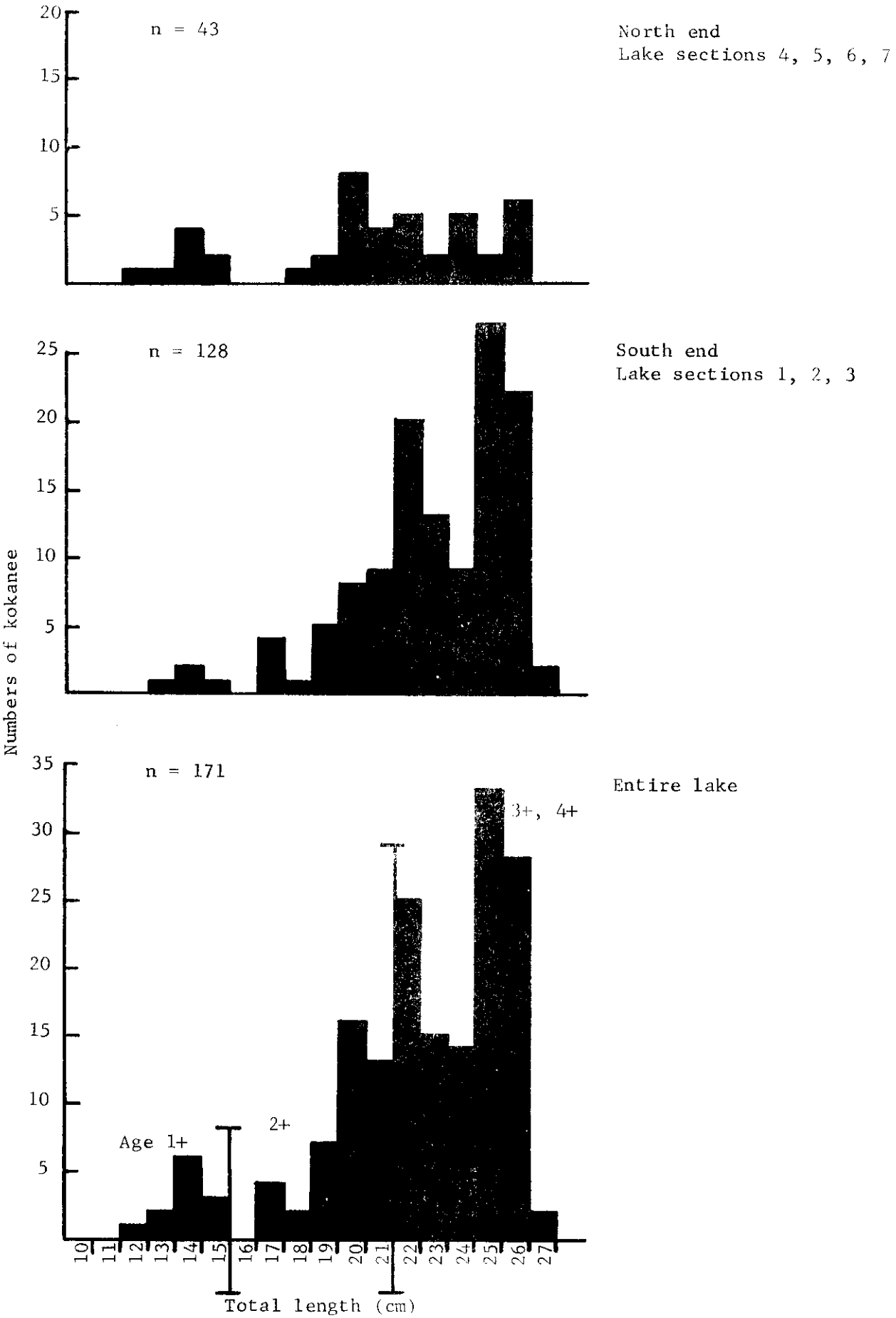

Figure 14. Length and age frequencies of kokanee collected from gill net catches in Pend Oreille Lake during October 1974.

Table 4. Age class composition (derived from length frequency histograms) and mean size of kokanee taken in Pend Oreille Lake during the summer and fall of 1974 with gill nets.

Month	Age class	Length range (mm)	Weighted mean size (mm)	Sample size
June	1^+	120-159	---	--
	2^+	160-199	180.80	25
	3^+, 4^+	200-250	221.63	168
July	1^+	120-159	130.32	38
	2^+	160-199	182.90	20
	3^+, 4^+	200-280	225.04	133
August	1^+	120-159	138.27	239
	2^+	160-209	187.61	227
	3^+, 4^+	210-270	238.81	263
September	1^+	120-159	142.96	78
	2^+	160-219	201.45	42
	3^+, 4^+	220-270	240.22	122
October	1^+	120-159	144.82	12
	2^+	160-219	201.86	42
	3^+, 4^+	220-270	247.86	117

Table 5. Increment of growth, derived from length frequency histograms, by monthly interval for kokanee taken in Pend Oreille Lake during the summer and fall of 1974 with gill nets.

Age	Time period	Increment of growth (mm)	Average growth rate/month (mm)
1^+	June-July	--	
	July-August	7.95	
	August-September	4.69	3.63
	September-October	1.86	
Total		14.50	
2^+	June-July	2.10	
	July-August	4.71	
	August-September	13.84	5.27
	September-October	0.41	
Total		21.06	
3^+, 4^+	June-July	3.41	
	July-August	13.77	
	August-September	1.41	6.56
	September-October	7.64	
Total		26.23	

Table 6. Summary of the stomach analysis of kokanee taken with gill nets and from the angler catch in Lake Pend Oreille during the summer and fall of 1974.

Month	Method of collection	Lake sections	Age class	Total stomachs analyzed	No. of empty stomachs	No. of stomachs with identifiable organisms	Percent of stomachs that contain identifiable organisms in which a particular organism was found	
June	Gill nets	1, 2, 3	2+	11	0 (0%)	7 (64%)	100	Bosmina sp.
			3+, 4+	39	5 (13%)	18 (46%)	94	Bosmina sp.
							6	Ant Heads
June	Gill nets	4, 5	1+	3	0 (0%)	1 (33%)	100	Insect Parts
			2+	2	1 (50%)	0 (0%)		---
			3+, 4+	25	9 (36%)	12 (48%)	92	Bosmina sp.
							8	Daphnia sp.
							8	Cyclops sp.
							8	Copepods
July	Gill nets	1, 2, 3	2+	12	4 (33%)	1 (8%)	100	Bosmina sp.
			3+, 4+	42	24 (57%)	6 (14%)	33	Bosmina sp.
							33	Daphnia sp.
							33	Insect Parts
							17	Cladocerans
							17	Copepods
July	Gill nets	4, 5, 6 7	1+	3	0 (0%)	2 (67%)	100	Bosmina sp.
							50	Copepods
			2+	7	3 (43%)	3 (43%)	67	Diaptomus sp.
							33	Bosmina sp.
							33	Daphnia sp.
							33	Copepods
July	Gill nets		3+, 4+	26	13 (50%)	3 (12%)	100	Copepods
							33	Bosmina sp.
							33	Daphnia sp.
Aug	Gill nets	1, 2, 3	1+	3	2 (67%)	0 (0%)		---
			2+	55	21 (38%)	21 (38%)	90	Daphnia sp.
							14	Epischura sp.
							5	Cladocerans
							5	Diaptomus sp.
			3+, 4+	78	40 (51%)	21 (27%)	90	Daphnia sp.
							10	Ephischura sp.
							5	Bosmina sp.

Table 6. Summary of the stomach analysis of kokanee taken with gill nets and from the angler catch in Lake Pend Oreille during the summer and fall of 1974 (continued).

Month	Method of collection	Lake sections	Age class	Total stomachs analyzed	No. of empty stomachs	No. of stomachs with identifiable organisms	Percent of stomachs that contain identifiable organisms in which a particular organism was found	
Aug	Angler catch	5, 6, 7	2+	23	0 (0%)	23 (100%)	100	Daphnia sp.
							17	Ephischura sp.
			3+, 4+	73	1 (1%)	63 (86%)	89	Daphnia sp.
							25	Epischura sp.
							11	Diaptomus sp.
							6	Leptodora sp.
							5	Copepods
Aug	Gill nets	4, 5, 6 7	2+	20	7 (35%)	7 (35%)	100	Daphnia sp.
							14	Epischura sp.
Sept	Gill nets	1, 2, 3	1+	3	0 (0%)	3 (100%)	100	Daphnia sp.
							100	Epischura sp.
			2+	21	15 (71%)	4 (19%)	75	Daphnia sp.
							50	Epischura sp.
			3+, 4+	59	39 (66%)	14 (24%)	93	Daphnia sp.
							14	Epischura sp.
Sept	Gill nets	4, 5, 6 7	1+	18	2 (11%)	14 (78%)	100	Daphnia sp.
							50	Epischura sp.
			2+	12	5 (42%)	5 (42%)	80	Daphnia sp.
							20	Epischura sp.
			3+, 4+	22	10 (45%)	8 (36%)	63	Daphnia sp.
							63	Epischura sp.
Oct	Gill nets	1, 2, 3	1+	4	0 (0%)	1 (25%)	100	Copepods
							100	Insect Parts
			2+	22	11 (50%)	7 (32%)	100	Epischura sp.
			3+, 4+	40	25 (63%)	8 (20%)	100	Epischura sp.
							13	Daphnia sp.
Oct	Gill nets	4, 5, 6 &	1+	8	3 (38%)	1 (13%)	100	Insect Parts
			2+	11	5 (45%)	3 (27%)	100	Insect Parts
							33	Epischura sp.
							33	Cladocerans
							33	Copepods

Table 6. Summary of the stomach analysis of kokanee taken with gill nets and from the angler catch in Lake Pend Oreille during the summer and fall of 1974 (continued).

Month	Method of collection	Lake sections	Age class	Total stomachs analyzed	No. of empty stomachs	No. of stomachs with identifiable organisms	Percent of stomachs that contain identifiable organisms in which a particular organism was found
			3+, 4+	14	10 (71%)	0 (0%)	---
Totals				656	255 (39%)	257 (39%)	
Stomachs taken from gill nets				560	254 (45%)	171 (31%)	
Stomachs taken from angler catch				96	1 (1%)	86 (90%)	

stomachs in July (Table 6). Daphnia sp. was the most common food item found in the stomachs beginning in August and continuing through September with Epischura sp. being second in abundance. Third in abundance during August and September was Diaptomus sp., Epischura sp. and insect remains predominated the diet in October with a few Daphnia sp. recorded in the stomachs (Table 6). No Mysis shrimp were found in any of the kokanee stomachs examined.

From the kokanee stomachs that we examined. there appears to be little difference in the food item selection among age classes although there tended to be more insect remains in the age 1+ kokanee than the other age classes. Also there was no apparent difference in food selection between kokanee taken from the north and south end of the lake.

Abundance and Distribution of Mysis relicta

The number of mysids per m^3, collected from trawling, has increased from 1969 to 1974 in Pend Oreille Lake (Table 7). Trawling attempts in June have yielded the most shrimp primarily because of the lower water temperatures in the epilimnion at that time of year. When the lake begins to stratify in July and August, it is more difficult to collect the shrimp.

The south end of Pend Oreille Lake has yielded most of the shrimp taken in the trawls (Table 7).

DISCUSSION:

Fish Movement

Movement patterns were difficult to assess in Pend Oreille Lake from echo-sounding data. Fish appeared to be heavily concentrated in the south end of the lake in January but the February estimate indicated a more even distribution of fish in the lake except for the extreme north end. What appeared to be a change in distribution from January to February may have actually been the result of added recruitment of fish to the echosounding gear because there was about a two-fold increase in the estimate between the 2 months.

By March the fish population appeared to stabilize and remained that way through September. A significant drop in numbers occurred in October suggesting a loss of fish to the echosounding gear perhaps because ripening and/or spawning kokanee left the transect sampling area. During that period when the fish population appeared to be stable in numbers (March through September) there were significant changes in numbers of fish from lake section to lake section suggesting continual monthly fish movement.

Mysis Shrimp

Mysis shrimp appear to be increasing in numbers in Pend Oreille Lake. Overall densities have shown an increase from 0.1 mysids per m^3 in 1972 to 1.2 mysids per m^3 in 1974. Of the 656 kokanee stomachs examined from the lake in 1974, no mysids were found. Very few kokanee collected either from gill nets or from the angler catch in the lake in 1974 measured longer than 280 mm (11 in). Studies in Priest Lake, Idaho have indicated that only kokanee longer than

Table 7. Summary of the number of mysids (Mysis relicta) per m^3 collected with a shrimp trawl in Pend Oreille Lake from 1969 to 1974.

Trawl location	Number of Mysids per m^3 1969 September	1970	1971 July, August	1972 September	1973 June	1973 July	1974 June
State Fish Hatchery					--	0.01	--
Contest Point					--	0.0	0.1
Bottle Bay					0.7	0.0	0.1
Anderson Point				0.0	0.9	0.0	0.7
Glengary Bay					--	0.0	0.1
Ellisport Bay			0.0		1.1	0.0	--
Sheepherder Point					0.8	0.0	--
Garfield Bay				0.0	1.1	0.0	0.7
Cape Horn Resort					0.05	0.0	1.4
Scenic Bay					1.4	0.0	2.8
Blackwell Point				0.2	1.0	0.0	2.2
Idelwilde Bay	0.0				1.2	0.01	2.0
Echo Bay					1.5	0.0	--
Cement Plant					1.3	0.0	--
Average	0.0		0.0	0.1	1.0	0.0	1.2

No Recovery Attempts

280 mm (11 in) actively consumed Mysis. Evidence collected in Pend Oreille Lake indicates that the kokanee have not attained an adequate length to begin actively feeding on Mysis, assuming the shrimp are in adequate abundance in the lake.

Gear Limitations

The fish population estimates, obtained from echosounding, for Pend Oreille Lake showed a consistent trend from March through September (except July) indicating that the estimates were relatively precise. This suggests if the population was relatively static through that time period, that the sampling technique (stratified random sampling) was adequate. But because of the way the cone volume was computed (using a 22° beam angle), I have reason to doubt the accuracy of the estimates. Using a 22° beam angle does not accurately depict the shape of the cone to accurately determine volume. Cone shape is dependent on the individual transducer characteristics which effects volume sampled. The volume of water sampled is also a function of depth, size and aspect of the fish targets, the transmitter power and receiver gain of the sounder and the minimum threshold for counting.

To check the accuracy of the echosounding equipment presently used on Pend Oreille Lake, it will be necessary to employ some more sophisticated acoustical gear that can compute cone volume electronically and relate that volume to a particular size of fish being sounded.

Good quantitative information concerning a particular fish species using echosounding is dependent on an accurate assessment of the fish species being sounded. Vertical gill nets used on Pend Oreille Lake in 1974 averaged 7.6 fish per net indicating low efficiency of the collecting gear. Also the nets were only effective in catching fish species longer than 110 mm (4.3 in) eliminating the age 0 fish from the sample. Forty-five percent of the kokanee stomachs collected from gill net catches were empty suggesting a considerable amount of regurgitation occurs in the stomachs of kokanee collected from gill nets.

To obtain a better assessment of species composition, kokanee food habits and a larger representation of the respective age classes of kokanee in Pend Oreille Lake, I would suggest that some form of midwater trawl would be more efficient and effective than gill netting.

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